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(54) Title: SUBSTITUTED HETEROCYCLIC AMIDES

(57) Abstract: This application relates to a compound of formula (I) (or a pharmaceutically acceptable salt thereof) as defined herein, pharmaceutical compositions thereof, and its use as an inhibitor of factor Xa, as well as a process for its preparation and intermediates therefor.

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## SUBSTITUTED HETEROCYCLIC AMIDES

This application claims the benefit of U.S. Provisional  
5 Application No. 60/221,092, filed July 27, 2000, which is  
incorporated by reference herein in its entirety.

This invention relates to anticoagulant substituted  
heterocyclic amides which demonstrate activity as inhibitors  
of factor Xa and, accordingly, which are useful antithrom-  
10 botics in mammals. In particular it relates to substituted  
heterocyclic amides having high anticoagulant activity, and  
antithrombotic activity. Thus, this invention relates to  
new substituted heterocyclic amides which are inhibitors of  
factor Xa, pharmaceutical compositions containing the  
15 substituted heterocyclic amides as active ingredients, and  
the use of the substituted heterocyclic amides as  
anticoagulants for prophylaxis and treatment of  
thromboembolic disorders such as venous thrombosis,  
pulmonary embolism, arterial thrombosis, in particular  
20 myocardial ischemia, myocardial infarction and cerebral  
thrombosis, general hypercoagulable states and local  
hypercoagulable states, such as following angioplasty and  
coronary bypass operations, and generalized tissue injury as  
it relates to the inflammatory process. In addition, the  
25 substituted heterocyclic amides are useful as anticoagulants  
in *in vitro* applications.

The process of blood coagulation, thrombosis, is  
triggered by a complex proteolytic cascade leading to the  
formation of thrombin. Thrombin proteolytically removes  
30 activation peptides from the A $\alpha$ -chains and the B $\beta$ -chains of  
fibrinogen, which is soluble in blood plasma, initiating  
insoluble fibrin formation. The formation of thrombin from  
prothrombin is catalyzed by factor Xa.

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Anticoagulation currently is achieved by the administration of heparins and coumarins. Parenteral pharmacological control of coagulation and thrombosis is based on inhibition of thrombin through the use of heparins.

5 Heparins act indirectly on thrombin by accelerating the inhibitory effect of endogenous antithrombin III (the main physiological inhibitor of thrombin). Because antithrombin III levels vary in plasma and because clot-bound thrombin seems resistant to this indirect mechanism, heparins can be

10 an ineffective treatment. Because coagulation assays are believed to be associated with efficacy and with safety, heparin levels must be monitored with coagulation assays (particularly the activated partial thromboplastin time (APTT) assay). Coumarins impede the generation of thrombin

15 by blocking the posttranslational gamma-carboxylation in the synthesis of prothrombin and other proteins of this type. Because of their mechanism of action, the effect of coumarins can only develop slowly, 6-24 hours after administration. Further, they are not selective

20 anticoagulants. Coumarins also require monitoring with coagulation assays (particularly the prothrombin time (PT) assay).

Recently, interest has grown in small synthetic molecules which demonstrate potent direct inhibition of

25 thrombin and factor Xa. See, B. Y. Zhu; R. M. Scarborough Current Opinion in Cardiovascular, Pulmonary & Renal Investigational Drugs, (1999), 1(1), 63-88, Recent Advances in Inhibitors of Factor Xa in the Prothrombinase Complex.

Although the heparins and coumarins are effective

30 anticoagulants, there still exists a need for anticoagulants which act selectively on factor Xa or thrombin, and which, independent of antithrombin III, exert inhibitory action shortly after administration, preferably by an oral route,

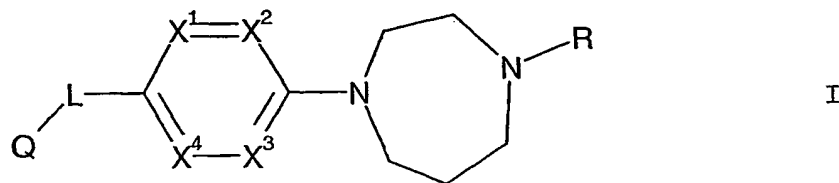
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and do not interfere with lysis of blood clots, as required to maintain hemostasis.

The present invention is directed to the discovery that the substituted heterocyclic amides of the present  
 5 invention, as defined below, are potent inhibitors of factor Xa which may have high bioavailability following oral administration.

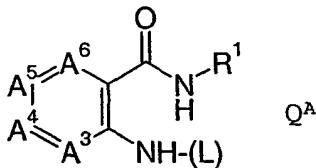
According to the invention there is provided a compound of formula I

10



or a pharmaceutically acceptable salt thereof, wherein

L is carbonyl or methylene and Q (showing L at its  
 15 point of attachment) is a residue of formula Q<sup>A</sup>,



in which

20 A<sup>3</sup>, A<sup>4</sup>, A<sup>5</sup> and A<sup>6</sup>, together with the two carbons to which they are attached, complete a substituted benzene in which A<sup>3</sup> is CR<sup>3</sup>, A<sup>4</sup> is CR<sup>4</sup>, A<sup>5</sup> is CR<sup>5</sup>, and A<sup>6</sup> is CR<sup>6</sup>;  
 wherein

R<sup>3</sup> is hydrogen, fluoro, chloro, methyl, methoxy,  
 25 hydroxy or carboxy;

one of R<sup>4</sup> and R<sup>5</sup> is hydrogen, (1-4C)alkyl, halo, trifluoromethyl, trifluoromethoxy, cyano, hydroxymethyl,

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(1-3C)acyl,  $R^fO-$ ,  $R^fO_2C-$ ,  $R^fO_2C-CH_2-$ ,  $R^fO_2C-CH_2-O-$ , methylthio or  $R^gNH-$ ;

the other of  $R^4$  and  $R^5$  is hydrogen, halo or methyl; and  $R^6$  is hydrogen, fluoro, chloro, methyl or methoxy;

5 in which  $R^f$  is hydrogen, (1-4C)alkyl or benzyl;  $R^g$  is hydrogen, (1-3C)acyl, trifluoroacetyl, methoxyacetyl, or  $R^hSO_h-$  (wherein  $h$  is 1 or 2); and  $R^h$  is (1-4C)alkyl, trifluoromethyl, phenyl, amino, methylamino or dimethylamino; or

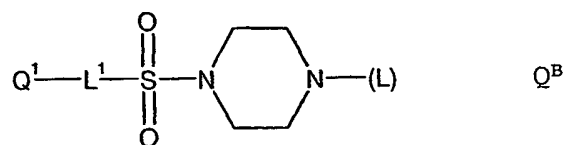
10  $A^3$ ,  $A^4$ ,  $A^5$  and  $A^6$ , together with the two carbons to which they are attached, complete a substituted heteroaromatic ring in which one of  $A^3$ ,  $A^4$ ,  $A^5$  and  $A^6$  is N, and each of the others is  $CR^3$ ,  $CR^4$ ,  $CR^5$  or  $CR^6$ , respectively; wherein

15 each of  $R^3$ ,  $R^4$ ,  $R^5$  and  $R^6$  is independently hydrogen or methyl, or one of  $R^3$ ,  $R^4$ ,  $R^5$  and  $R^6$  attached to a carbon which is not bonded to an N-atom is chloro and the others are hydrogen;

$R^1$  is 2-pyridinyl (which may bear a methyl, methoxy, 20 methylthio, fluoro or chloro substituent at the 5-position), or  $R^1$  is 3-pyridinyl (which may bear a methyl, fluoro or chloro substituent at the 6-position), or  $R^1$  is phenyl (which may bear one, two or three substituents at the 3-, 4- or 5-position(s) independently selected from halo, cyano, 25 carbamoyl, methyl, methoxy, difluoromethoxy, hydroxymethyl, formyl, vinyl, amino, hydroxy and 3,4-methylenedioxy; and in addition the phenyl may bear a 2-chloro or 2-fluoro substituent), or  $R^1$  is 6-indolyl (which may bear a chloro or methyl substituent at the 3-position); or

30 L is carbonyl and Q (showing L at its point of attachment) is a residue of formula  $Q^B$ ,

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wherein:

5  $Q^1$  is phenyl, benzo[b]thiophen-2-yl or naphthalen-2-yl  
any of which may bear one or more halo, trifluoromethyl,  
methoxy or methyl substituents;

$L^1$  is a direct bond, methylene, ethylene or ethen-1,2-  
diyl;

10 one or two of  $x^1$ ,  $x^2$ ,  $x^3$  and  $x^4$  is N; and each of the  
others of  $x^1$ ,  $x^2$ ,  $x^3$  and  $x^4$  is CH; and

$R$  is hydrogen, (1-3C)alkyl, (1-3C)acyl, acetyloxy-  
acetyl, aminoacetyl, hydroxyacetyl, {(1-4C)alkoxy}carbonyl,  
{(1-4C)alkoxy}carbonylmethyl,  $R^a R^b N-CO-$  or  $R^j SO_2-$ , wherein  
each of  $R^a$  and  $R^b$  is independently hydrogen or (1-3C)alkyl,  
15 or  $R^a R^b N-$  is 1-azetidiny, 1-pyrrolidinyl, 1-piperidinyl,  
4-morpholinyl or 4-thiomorpholinyl;  $j$  is 1 or 2; and  $R^j$  is  
(1-4C)alkyl, trifluoromethyl, amino, methylamino or  
dimethylamino.

20 As used herein, the expression a compound of formula I  
or the expression a compound of the invention includes the  
compound and any conventional prodrug thereof, as well as a  
pharmaceutically acceptable salt of said compound or  
prodrug.

25 A particular compound of formula I is one wherein  
when  $Q$  is  $Q^A$ ,  
 $R^3$  is hydrogen;  
one of  $R^4$  and  $R^5$  is hydrogen, (1-4C)alkyl, halo,  
trifluoromethyl, trifluoromethoxy, cyano, hydroxymethyl,  
30 (1-3C)acyl,  $R^f O-$ ,  $R^f O_2 C-$ ,  $R^f O_2 C-CH_2-$ ,  $R^f O_2 C-CH_2-O-$ ,  
methylthio or  $R^g NH-$  in which  $R^g$  is hydrogen, (1-3C)acyl, or

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$R^hSO_2-$ ; and  $R^h$  is (1-4C)alkyl, trifluoromethyl, amino, methylamino or dimethylamino;

the other of  $R^4$  and  $R^5$  is hydrogen, halo or methyl; and  $R^6$  is hydrogen;

5 or

$A^6$  is N, and each of the others is  $CR^3$ ,  $CR^4$  and  $CR^6$ , respectively, in which  $R^3$  and  $R^4$  is each hydrogen and  $R^6$  is hydrogen or methyl; and

when Q is  $Q^B$ ,  $Q^{1L1}$  is trans-styryl (which may bear one  
10 or more halo, methoxy or methyl substituents on the aromatic ring), benzo[b]thiophen-2-yl (which may bear one or more halo, methoxy or methyl substituents at the 5- and/or 6-position) or naphthalen-2-yl (which may bear one or more halo, methoxy or methyl substituents at the 6- and/or  
15 7-position); and

R is hydrogen, (1-3C)alkyl, (1-3C)acyl, acetyloxy-acetyl, hydroxyacetyl, methoxycarbonyl, ethoxycarbonyl, {(1-4C)alkoxy}carbonylmethyl,  $R^aR^bN-CO-$  or  $R^jSO_2-$ , wherein each of  $R^a$  and  $R^b$  is independently hydrogen or (1-3C)alkyl,  
20 or  $R^aR^bN-$  is 1-azetidiny, 1-pyrrolidinyl, 1-piperidinyl, 4-morpholinyl or 4-thiomorpholinyl; and  $R^j$  is (1-4C)alkyl, trifluoromethyl, amino, methylamino or dimethylamino.

A more particular compound, or salt thereof, as described above is one wherein

25 when Q is  $Q^A$ ,

$A^3$  is  $CR^3$ ,  $A^4$  is  $CR^4$ ,  $A^5$  is  $CR^5$ , and  $A^6$  is  $CR^6$ ; wherein each of  $R^3$ ,  $R^4$  and  $R^6$  is hydrogen and  $R^5$  is fluoro, chloro, methyl, acetyl, methoxycarbonyl or carboxy; or each of  $R^3$ ,  $R^5$  and  $R^6$  is hydrogen and  $R^4$  is methoxycarbonyl or carboxy;  
30 or each of  $R^3$  and  $R^6$  is hydrogen and each of  $R^4$  and  $R^5$  is fluoro; or

$A^6$  is N, and each of  $A^3$ ,  $A^4$  and  $A^5$  is CH; and

$R^1$  is 2-pyridinyl which bears a fluoro, chloro or methyl substituent at the 5-position; and

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when Q is Q<sup>B</sup>,

Q<sup>1</sup> is 6-chloronaphthalen-2-yl and L<sup>1</sup> is a direct bond;  
each of X<sup>1</sup> and X<sup>2</sup> is N; and each of X<sup>3</sup> and X<sup>4</sup> is CH; or  
each of X<sup>1</sup> and X<sup>3</sup> is N; and each of X<sup>2</sup> and X<sup>4</sup> is CH; or  
5 each of X<sup>1</sup> and X<sup>4</sup> is N; and each of X<sup>3</sup> and X<sup>4</sup> is CH; or  
X<sup>1</sup> is N and each of X<sup>2</sup>, X<sup>3</sup> and X<sup>4</sup> is CH; or  
X<sup>2</sup> is N and each of X<sup>1</sup>, X<sup>3</sup> and X<sup>4</sup> is CH; and

R is hydrogen, methyl, ethyl, acetyl, acetoxycetyl,  
hydroxyacetyl, t-butoxycarbonylmethyl, methylsulfonyl or  
10 dimethylaminosulfonyl.

One particular compound, or salt thereof, according to  
any of the above descriptions is one wherein Q is Q<sup>A</sup>; and  
more particularly wherein

L is carbonyl;

15 A<sup>3</sup> is CR<sup>3</sup>, A<sup>4</sup> is CR<sup>4</sup>, A<sup>5</sup> is CR<sup>5</sup>, and A<sup>6</sup> is CR<sup>6</sup>; wherein  
each of R<sup>3</sup>, R<sup>4</sup> and R<sup>6</sup> is hydrogen and R<sup>5</sup> is fluoro, chloro,  
methyl, acetyl, methoxycarbonyl or carboxy (particularly  
wherein R<sup>5</sup> is fluoro); or each of R<sup>3</sup>, R<sup>5</sup> and R<sup>6</sup> is hydrogen  
and R<sup>4</sup> is methoxycarbonyl or carboxy;

20 R<sup>1</sup> is 2-pyridinyl which bears a fluoro, chloro or  
methyl substituent (particularly a chloro substituent) at  
the 5-position; and

each of X<sup>1</sup> and X<sup>3</sup> is N; and each of X<sup>2</sup> and X<sup>4</sup> is CH; or  
each of X<sup>1</sup> and X<sup>4</sup> is N; and each of X<sup>3</sup> and X<sup>4</sup> is CH; or  
25 X<sup>1</sup> is N and each of X<sup>2</sup>, X<sup>3</sup> and X<sup>4</sup> is CH; or  
X<sup>2</sup> is N and each of X<sup>1</sup>, X<sup>3</sup> and X<sup>4</sup> is CH; and

R is hydrogen, methyl, ethyl, acetyl, acetoxycetyl,  
hydroxyacetyl, methylsulfonyl or dimethylaminosulfonyl.

A specific compound, or salt thereof, wherein Q is Q<sup>A</sup>  
30 is any one of those provided in the Examples, especially  
that of Example 1, 14, 23, 25 or 32.

Another particular compound, or salt thereof, according  
to the above descriptions is one wherein Q is Q<sup>B</sup>; and more



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particularly wherein each of  $X^1$  and  $X^2$  is N and each of  $X^3$  and  $X^4$  is CH, and R is hydrogen or methyl.

For any compound described herein according to a formula which includes the values  $X^1$ - $X^4$ , when one of  $X^1$ - $X^4$  is N, one particular set of values for  $X^1$ - $X^4$  is  $X^1$  is N and each of  $X^2$ - $X^4$  is CH; and another particular set of values for  $X^1$ - $X^4$  is  $X^2$  is N and each of  $X^1$  and  $X^3$ - $X^4$  is CH.

For any compound described herein according to a formula which includes the values  $X^1$ - $X^4$ , when two of  $X^1$ - $X^4$  is N, one particular set of values for  $X^1$ - $X^4$  is each of  $X^1$  and  $X^3$  is N and each of  $X^2$  and  $X^4$  is CH; another particular set of values for  $X^1$ - $X^4$  is each of  $X^1$  and  $X^4$  is N and each of  $X^2$  and  $X^3$  is CH; and a further particular set of values for  $X^1$ - $X^4$  is each of  $X^1$  and  $X^2$  is N and each of  $X^3$  and  $X^4$  is CH.

A pharmaceutically acceptable salt of a compound of the instant invention is one which is the acid addition salt of a basic compound of formula I with an inorganic or organic acid which affords a physiologically acceptable anion or which is the salt formed by an acidic compound of formula I with a base which affords a physiologically acceptable cation and provides a particular aspect of the invention. Examples of such acids and bases are provided hereinbelow.

As an additional aspect of the invention there is provided a pharmaceutical formulation comprising in association with a pharmaceutically acceptable carrier, diluent or excipient, a compound of formula I (or a pharmaceutically acceptable salt thereof) as provided in any of the descriptions herein.

In addition, there is provided the use of a compound of formula I (or prodrug or salt) as described herein as an active ingredient in the manufacture of a medicament for use in producing an anticoagulant or antithrombotic effect.

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The present invention also provides a method of inhibiting coagulation in a mammal comprising administering to a mammal in need of treatment, a coagulation inhibiting dose of a compound of formula I having any of the definitions herein.

The present invention further provides a method of inhibiting factor Xa comprising administering to a mammal in need of treatment, a factor Xa inhibiting dose of compound of formula I having any of the definitions herein.

Further, the present invention provides a method of treating a thromboembolic disorder comprising administering to a mammal in need of treatment, an effective dose of a compound of formula I having any of the definitions herein.

Also, there is provided a compound of formula I (or prodrug or salt) having any of the definitions herein for use as an antithrombotic agent.

In addition, there is provided the use of a compound of formula I having any of the definitions herein for the manufacture of a medicament for treatment of a thromboembolic disorder.

As an additional feature of the invention there is provided a pharmaceutical formulation comprising in association with a pharmaceutically acceptable carrier, diluent or excipient, a prodrug of a compound of formula I (or of a pharmaceutically acceptable salt thereof) as provided in any of the descriptions herein.

In this specification, the following definitions are used, unless otherwise described: Halo is fluoro, chloro, bromo or iodo. Alkyl, alkoxy, etc. denote both straight and branched groups; but reference to an individual radical such as "propyl" embraces only the straight chain ("normal") radical, a branched chain isomer such as "isopropyl" being specifically denoted.

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Particular values are listed below for radicals, substituents, and ranges, for illustration only, and they do not exclude other defined values or other values within defined ranges for the radicals and substituents. Thus, a particular value for halo is fluoro, chloro or bromo; for (1-3C)alkyl is methyl, ethyl, propyl or isopropyl; for (1-4C)alkyl is methyl, ethyl, propyl, isopropyl, butyl, isobutyl or t-butyl; for (1-4C)alkoxy is methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy or t-butoxy; and for (1-3C)acyl is formyl, acetyl or propionyl.

It will be appreciated that certain compounds of formula I (or salts or prodrugs, etc.) may exist in, and be isolated in, isomeric forms, including tautomeric forms, cis- or trans-isomers, as well as optically active, racemic, or diastereomeric forms. It is to be understood that the present invention encompasses a compound of formula I in any of the tautomeric forms or as an a mixture thereof; or as a mixture of diastereomers, as well as in the form of an individual diastereomer, and that the present invention encompasses a compound of formula I as a mixture of enantiomers, as well as in the form of an individual enantiomer, any of which mixtures or form possesses inhibitory properties against factor Xa, it being well known in the art how to prepare or isolate particular forms and how to determine inhibitory properties against factor Xa by standard tests including those described below.

In addition, a compound of formula I (or salt or prodrug, etc.) may exhibit polymorphism or may form a solvate with water or an organic solvent. The present invention also encompasses any such polymorphic form, any solvate or any mixture thereof.

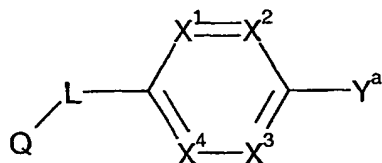
A prodrug of a compound of formula I may be one formed in a conventional manner with a functional group of the compound, such as with an amino, hydroxy or carboxy group.

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A compound of formula I may be prepared by processes which include processes known in the chemical art for the production of structurally analogous compounds or by a novel process described herein. A novel process described herein provides another aspect of the invention. A process for the preparation of a compound of formula I (or a pharmaceutically acceptable salt thereof) and novel intermediates for the manufacture of a compound of formula I provide further features of the invention and are illustrated by the following procedures in which the meanings of the generic radicals are as defined above, unless otherwise specified. It will be recognized that it may be preferred or necessary to prepare a compound of formula I in which a functional group is protected using a conventional protecting group, then to remove the protecting group to provide the compound of formula I.

Thus, there is provided a process for preparing a compound of formula I, or a pharmaceutically acceptable salt thereof, as provided in any of the above descriptions, which comprises:

(A) substituting the group  $Y^a$  of a compound of formula II,

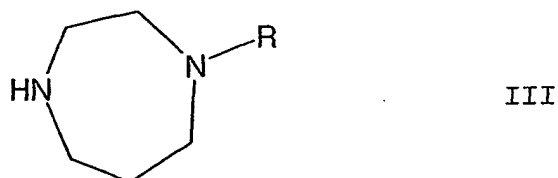


II

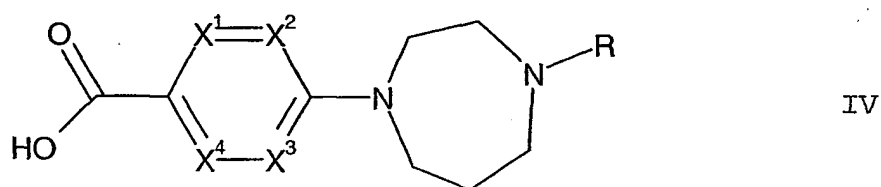
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in which  $Y^a$  is a leaving group for nucleophilic aromatic substitution, using an amine of formula III;

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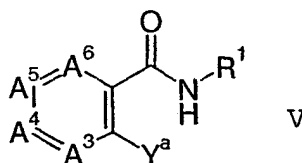
(B) for a compound of formula I in which L is carbonyl, acylating an amine of formula Q-H using a  
 5 corresponding acid of formula IV,



or an activated derivative thereof;

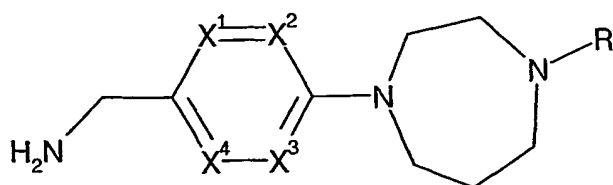
10 (C) for a compound of formula I in which R is not hydrogen, substituting the nitrogen of a corresponding compound in which R is hydrogen using a conventional procedure;

(D) for a compound of formula I in which L is  
 15 methylene and Q is Q<sup>A</sup>, substituting the group Y<sup>a</sup> of a compound of formula V



20 in which Y<sup>a</sup> is a leaving group for nucleophilic aromatic substitution with an amine of formula VI; or

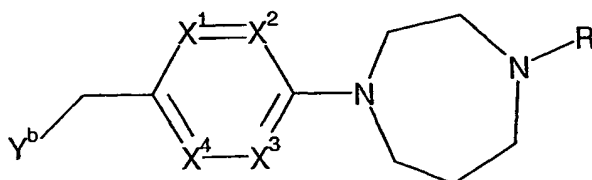
-13-



VI

alkylating an amine of formula Q-H directly, using a compound of formula VII,

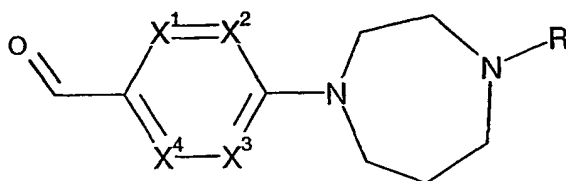
5



VII

in which Y<sup>b</sup> is a leaving group for nucleophilic substitution, or indirectly by reductive alkylation using an aldehyde of formula VIII;

10



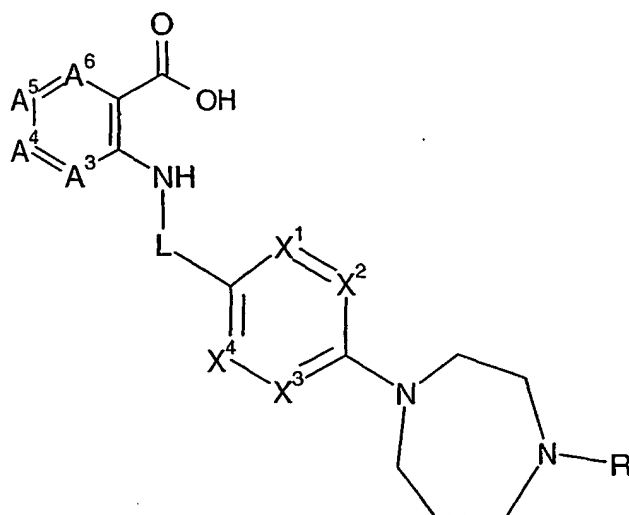
VIII

or

15

(E) for a compound of formula I in which Q is Q<sup>A</sup>, acylating an amine of formula H<sub>2</sub>N-R<sup>1</sup>, or a deprotonated derivative thereof, using an acid of formula IX or an activated derivative thereof,

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IX

whereafter, for any of the above procedures, when a functional group of a starting material is protected using a protecting group, removing the protecting group;

whereafter, for any of the above procedures, when a pharmaceutically acceptable salt of a compound of formula I is required, it is obtained by reacting the basic form of a basic compound of formula I with an acid affording a physiologically acceptable counterion or the acidic form of an acidic compound of formula I with a base affording a physiologically acceptable counterion or by any other conventional procedure;

and wherein, unless otherwise specified, Q, L, X<sup>1</sup>-X<sup>4</sup>, and R have any of the values defined in any of the above descriptions.

As used herein, a leaving group "Y<sup>a</sup>" is a moiety which is displaced in an aromatic (or heteroaromatic) nucleophilic substitution reaction, for example a halo group (such as fluoro or chloro), an alkoxy group (such as methoxy), a sulfonate ester group (such as methylsulfonyloxy, p-toluyloxy, sulfonyloxy or trifluoromethylsulfonyloxy), or the reactive species derived from treating an alcohol with triphenylphosphine, diethyl azodicarboxylate and triethyl amine (in a

-15-

Mitsunobu reaction). The substitution may be carried out by heating a mixture of the reagents in a polar solvent, for example in dimethyl sulfoxide in a sealed tube as described at Example P1 and Example 84-F.

5 For a carboxylic acid, a typical activated derivative includes an ester (particularly a lower alkyl ester such as the methyl or ethyl ester), an acid halide (particularly the acid chloride), and an activated ester or anhydride (including the 4-nitrophenyl ester and an activated ester or  
10 anhydride derived from a coupling reagent), as well as (when the product is a urea) the isocyanate. Typical procedures include those described for preparation of intermediate compounds at Intermediate A-1 and Example 84-E.

For a compound of formula I in which R is (1-C)alkyl or  
15 {(1-4C)alkoxy}carbonylmethyl, a conventional procedure for substituting the nitrogen of a compound in which R is hydrogen comprises alkylating the nitrogen, for example by reductively alkylating the nitrogen with the requisite aldehyde or ketone or by alkylating the nitrogen with a  
20 reagent of formula  $R-Y^b$ , in which  $Y^b$  is a leaving group for nucleophilic substitution, for example as described at Example 79.

For a compound of formula I in which R is (1-3C)acyl, acetyloxyacetyl, aminoacetyl, hydroxyacetyl, {(1-4C)alkoxy}-  
25 carbonyl or  $R^aR^bN-CO-$ , a conventional procedure for substituting the nitrogen of a compound in which R is hydrogen comprises acylating the nitrogen using the requisite carboxylic acid or activated derivative thereof (in which a functional group may be protected), for example  
30 as described at Example 75 (and which may be followed by removal of the protecting group, for example as at Example 77).

For a compound of formula I in which R is  $R^jSO_j-$ , a conventional procedure for substituting the nitrogen of a



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compound in which R is hydrogen comprises treating the amine with the requisite sulfinyl or sulfonyl halide, for example using the chloride of formula  $R^jSO_j-Cl$  as described at Examples 82-83 for compounds in which j is 2.

5 As used herein, a leaving group " $Y^b$ " is a moiety which is displaced in a nucleophilic substitution reaction, for example a halo group (such as chloro, bromo or iodo), a sulfonate ester group (such as methylsulfonyloxy, p-toluyloxy, sulfonyloxy or trifluoromethylsulfonyloxy), or the reactive species derived from treating an alcohol with triphenylphosphine, diethyl azodicarboxylate and triethyl amine (in a Mitsunobu reaction).

A novel intermediate or starting material compound provides a further aspect of the invention. The various starting materials may be made by processes which include processes known in the chemical art for the production of structurally analogous compounds or by a novel process described herein or one analogous thereto.

20 Thus, one particular intermediate is a compound of formula II,

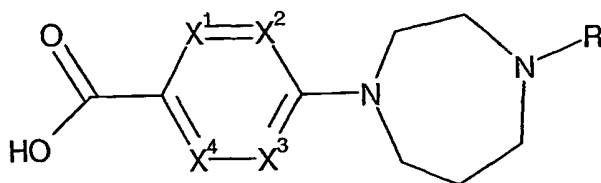


in which  $Y^a$  is a leaving group for nucleophilic aromatic substitution and Q, L,  $X^1-X^4$ , and R have any of the values defined in any of the above descriptions, or a derivative thereof in which a functional group other than  $Y^a$  is protected using a protecting group.

Another intermediate is an acid of formula IV,

30

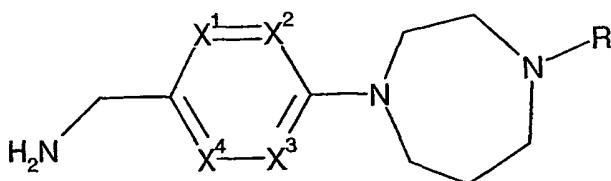
-17-



IV

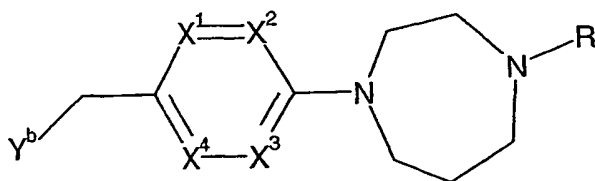
or an activated derivative thereof, or a salt of the acid or  
 activated derivative, in which  $X^1$ - $X^4$ , and R have any of the  
 5 values defined in any of the above descriptions, or a  
 derivative thereof in which a functional group other than  
 the carboxy group, or activated derivative thereof, is  
 protected using a protecting group.

A further intermediate is an amine of formula VI, or a  
 10 salt thereof; or



VI

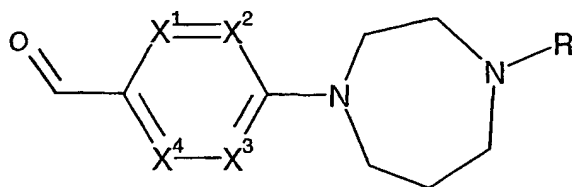
a compound of formula VII, or a salt thereof,  
 15



VII

in which  $Y^b$  is a leaving group for nucleophilic  
 substitution, or an aldehyde of formula VIII, or a salt  
 20 thereof;

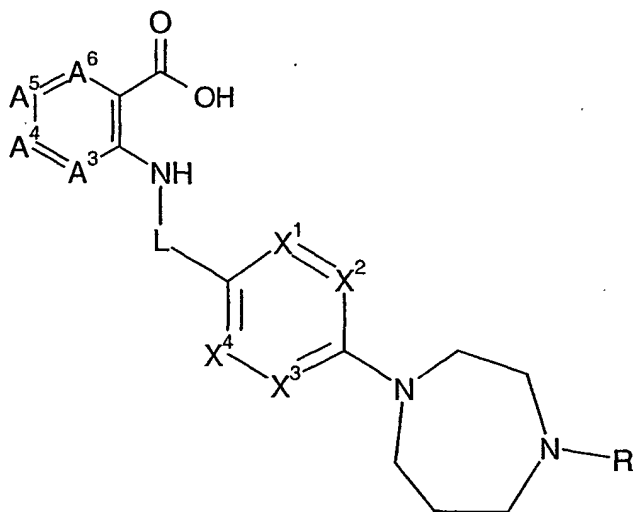
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VIII

in which  $X^1$ - $X^4$ , and R have any of the values defined in any of the above descriptions, or a derivative thereof in which a functional group other than the primary amino group of the compound of formula VI, the leaving group of the compound of formula VII, or the aldehyde group of the compound of formula VII, respectively, is protected using a protecting group.

Another intermediate is an acid of formula IX,

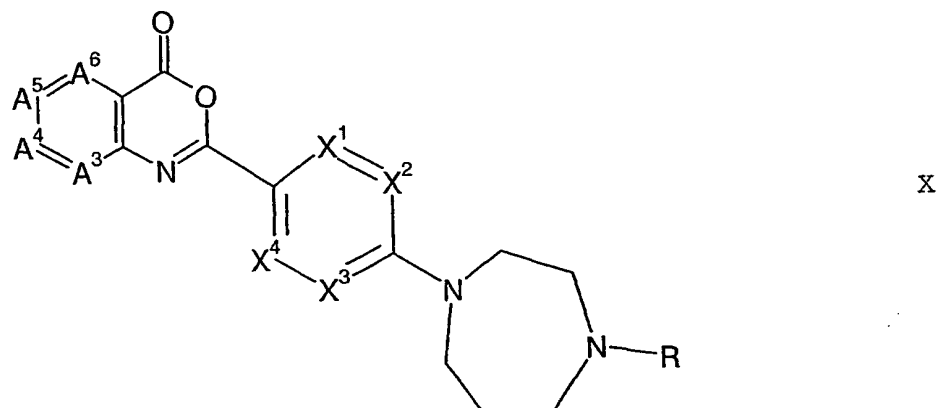


IX

or an activated derivative thereof, or a salt of the acid or activated derivative, in which  $A^3$ - $A^6$ , L,  $X^1$ - $X^4$ , and R have any of the values defined in any of the above descriptions, or a derivative thereof in which a functional group other than the carboxy group, or activated derivative thereof, is protected using a protecting group; and more particularly, the acid of formula IX in which L is carbonyl.

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For an acid of formula IX in which L is carbonyl, a particular activated derivative is a compound of formula X,

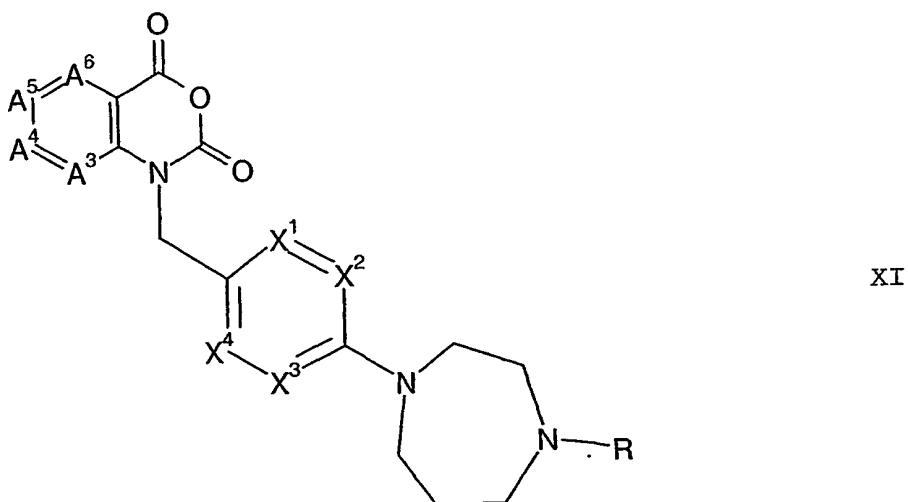


5

or a salt of the activated derivative, in which A<sup>3</sup>-A<sup>6</sup>, X<sup>1</sup>-X<sup>4</sup>, and R have any of the values defined in any of the above descriptions, or a derivative thereof in which a functional group other than the activated derivative of the carboxy group is protected using a protecting group.

10

For an acid of formula IX in which L is methylene, a particular activated derivative is a compound of formula XI,



15

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or a salt of the activated derivative, in which A<sup>3</sup>-A<sup>6</sup>,  
X<sup>1</sup>-X<sup>4</sup>, and R have any of the values defined in any of the  
above descriptions, or a derivative thereof in which a  
functional group other than the activated derivative of the  
5 carboxy group is protected using a protecting group.

As a further aspect of the invention, there is provided  
the use of a compound (or activated and/or protected  
derivative thereof or salt of the compound or derivative) of  
formula II, IV, VI, VII, VIII, IX, X or XI as a starting  
10 material in the preparation of an inhibitor of factor Xa.

As mentioned above, a compound corresponding to a  
compound of formula I but in which a functional group is  
protected may serve as an intermediate for a compound of  
formula I. Accordingly, such a protected intermediate for a  
15 novel compound of formula I provides a further aspect of the  
invention. Thus, as one particular aspect of the invention,  
there is provided a compound corresponding to a novel  
compound of formula I as defined above in which there is a  
hydroxy, but in which the corresponding substituent is -OPP  
20 in place of hydroxy, wherein PP is a phenol protecting group  
other than methyl. Phenol protecting groups are well known  
in the art, for example as described in T.W. Greene and  
P.G.M. Wuts, "Protecting Groups in Organic Synthesis"  
(1991). Further, PP may denote a functionalized resin, for  
25 example as disclosed in H.V. Meyers, et al., Molecular  
Diversity, (1995), 1, 13-20.

As mentioned above, the invention includes a  
pharmaceutically acceptable salt of the factor Xa inhibiting  
compound defined by the above formula I. A basic compound  
30 of this invention possesses one or more functional groups  
sufficiently basic to react with any of a number of  
inorganic and organic acids affording a physiologically  
acceptable counterion to form a pharmaceutically acceptable  
salt. Acids commonly employed to form pharmaceutically

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acceptable acid addition salts are inorganic acids such as hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid, phosphoric acid, and the like, and organic acids such as p-toluenesulfonic acid, methanesulfonic acid, 5 oxalic acid, p-bromobenzenesulfonic acid, carbonic acid, succinic acid, citric acid, benzoic acid, acetic acid, and the like. Examples of such pharmaceutically acceptable salts thus are the sulfate, pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogenphosphate, 10 dihydrogenphosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, acetate, propionate, decanoate, caprylate, acrylate, formate, isobutyrate, caproate, heptanoate, propiolate, oxalate, malonate, succinate, suberate, sebacate, fumarate, maleate, butyne-1,4-dioate, hexyne-1,6- 15 dioate, benzoate, chlorobenzoate, methylbenzoate, dinitrobenzoate, hydroxybenzoate, methoxybenzoate, phthalate, sulfonate, xylenesulfonate, phenylacetate, phenylpropionate, phenylbutyrate, citrate, lactate, gamma-hydroxybutyrate, glycollate, tartrate, methanesulfonate, 20 propanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, mandelate, and the like. Preferred pharmaceutically acceptable acid addition salts include those formed with mineral acids such as hydrochloric acid, hydrobromic acid and sulfuric acid.

25 If not commercially available, a necessary starting material for the preparation of a compound of formula I may be prepared by a procedure which is selected from standard techniques of organic chemistry, including aromatic and heteroaromatic substitution and transformation, from 30 techniques which are analogous to the syntheses of known, structurally similar compounds, and techniques which are analogous to the above described procedures or procedures described in the Examples. It will be clear to one skilled in the art that a variety of sequences is available for the

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preparation of the starting materials. Starting materials which are novel provide another aspect of the invention.

Selective methods of substitution, protection and deprotection are well known in the art for preparation of a  
5 compound such as one of formula II.

Generally, a basic compound of the invention is isolated best in the form of an acid addition salt. A salt of a compound of formula I formed with an acid such as one of those mentioned above is useful as a pharmaceutically  
10 acceptable salt for administration of the antithrombotic agent and for preparation of a formulation of the agent. Other acid addition salts may be prepared and used in the isolation and purification of the compounds.

As noted above, the optically active isomers and  
15 diastereomers of the compounds of formula I are also considered part of this invention. Such optically active isomers may be prepared from their respective optically active precursors by the procedures described above, or by resolving the racemic mixtures. This resolution can be  
20 carried out by derivatization with a chiral reagent followed by chromatography or by repeated crystallization. Removal of the chiral auxiliary by standard methods affords substantially optically pure isomers of the compounds of the present invention or their precursors. Further details  
25 regarding resolutions can be obtained in Jacques, et al., Enantiomers, Racemates, and Resolutions, John Wiley & Sons, 1981.

The compounds of the invention are believed to selectively inhibit factor Xa over other proteinases and  
30 nonenzyme proteins involved in blood coagulation without appreciable interference with the body's natural clot lysing ability (the compounds have a low inhibitory effect on fibrinolysis). Further, such selectivity is believed to

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permit use with thrombolytic agents without substantial interference with thrombolysis and fibrinolysis.

The invention in one of its aspects provides a method of inhibiting factor Xa in a mammal comprising administering to a mammal in need of treatment an effective (factor Xa inhibiting) dose of a compound of formula I.

In another of its aspects, the invention provides a method of treating a thromboembolic disorder comprising administering to a mammal in need of treatment an effective (thromboembolic disorder therapeutic and/or prophylactic amount) dose of a compound of formula I.

The invention in another of its aspects provides a method of inhibiting coagulation in a mammal comprising administering to a mammal in need of treatment an effective (coagulation inhibiting) dose of a compound of formula I.

The factor Xa inhibition, coagulation inhibition and thromboembolic disorder treatment contemplated by the present method includes both medical therapeutic and/or prophylactic treatment as appropriate.

In a further embodiment, the invention relates to treatment, in a human or animal, of a condition where inhibition of factor Xa is required. The compounds of the invention are expected to be useful in mammals, including man, in treatment or prophylaxis of thrombosis and hypercoagulability in blood and tissues. Disorders in which the compounds have a potential utility are in treatment or prophylaxis of thrombosis and hypercoagulability in blood and tissues. Disorders in which the compounds have a potential utility, in treatment and/or prophylaxis, include venous thrombosis and pulmonary embolism, arterial thrombosis, such as in myocardial ischemia, myocardial infarction, unstable angina, thrombosis-based stroke and peripheral arterial thrombosis. Further, the compounds have expected utility in the treatment or prophylaxis of



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- atherosclerotic disorders (diseases) such as coronary arterial disease, cerebral arterial disease and peripheral arterial disease. Further, the compounds are expected to be useful together with thrombolytics in myocardial infarction.
- 5 Further, the compounds have expected utility in prophylaxis for reocclusion after thrombolysis, percutaneous transluminal angioplasty (PTCA) and coronary bypass operations. Further, the compounds have expected utility in prevention of rethrombosis after microsurgery. Further, the
- 10 compounds are expected to be useful in anticoagulant treatment in connection with artificial organs, including joint replacement, and cardiac valves. Further, the compounds have expected utility in anticoagulant treatment in hemodialysis and disseminated intravascular coagulation.
- 15 Further, the compounds may be useful in reducing the increased thrombin generation which occurs in the airways of patients with asthma; see, E.C. Gabazza, et al., Lung, (1999), 177(4), 253-262. A further expected utility is in rinsing or coating of catheters and mechanical devices used
- 20 in patients *in vivo*, and as an anticoagulant for preservation of blood, plasma and other blood products *in vitro*. Still further, the compounds have expected utility in other diseases where blood coagulation could be a fundamental contributing process or a source of secondary
- 25 pathology, such as cancer, including metastasis, inflammatory diseases, including arthritis, and diabetes. The anti-coagulant compound is administered orally or parenterally, e.g. by intravenous infusion (iv), intramuscular injection (im) or subcutaneously (sc).
- 30 The specific dose of a compound administered according to this invention to obtain therapeutic and/or prophylactic effects will, of course, be determined by the particular circumstances surrounding the case, including, for example,

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the compound administered, the rate of administration, the route of administration, and the condition being treated.

A typical daily dose for each of the above utilities is between about 0.01 mg/kg and about 1000 mg/kg. The dose  
5 regimen may vary e.g. for prophylactic use a single daily dose may be administered or multiple doses such as 3 or 5 times daily may be appropriate. In critical care situations a compound of the invention is administered by iv infusion at a rate between about 0.01 mg/kg/h and about 20 mg/kg/h  
10 and preferably between about 0.1 mg/kg/h and about 5 mg/kg/h.

The method of this invention also is practiced in conjunction with a clot lysing agent e.g. tissue plasminogen activator (t-PA), modified t-PA, streptokinase or urokinase.  
15 In cases when clot formation has occurred and an artery or vein is blocked, either partially or totally, a clot lysing agent is usually employed. A compound of the invention can be administered prior to or along with the lysing agent or subsequent to its use, and preferably further is  
20 administered along with aspirin to prevent the reoccurrence of clot formation.

The method of this invention is also practiced in conjunction with a platelet glycoprotein receptor (IIb/IIIa) antagonist, that inhibits platelet aggregation. A compound  
25 of the invention can be administered prior to or along with the IIb/IIIa antagonist or subsequent to its use to prevent the occurrence or reoccurrence of clot formation.

The method of this invention is also practiced in conjunction with aspirin. A compound of the invention can  
30 be administered prior to or along with aspirin or subsequent to its use to prevent the occurrence or reoccurrence of clot formation. As stated above, preferably a compound of the present invention is administered in conjunction with a clot lysing agent and aspirin.

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This invention also provides a pharmaceutical composition for use in the above described therapeutic method. A pharmaceutical composition of the invention comprises an effective factor Xa inhibiting amount of a  
5 compound of formula I in association with a pharmaceutically acceptable carrier, excipient or diluent.

The active ingredient in such formulations comprises from 0.1 percent to 99.9 percent by weight of the formulation. By "pharmaceutically acceptable" it is meant  
10 the carrier, diluent or excipient must be compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

For oral administration the antithrombotic compound is formulated in gelatin capsules or tablets which may contain  
15 excipients such as binders, lubricants, disintegration agents and the like. For parenteral administration the antithrombotic is formulated in a pharmaceutically acceptable diluent e.g. physiological saline (0.9 percent), 5 percent dextrose, Ringer's solution and the like.

20 The compound of the present invention can be formulated in unit dosage formulations comprising a dose between about 0.1 mg and about 1000 mg. Preferably the compound is in the form of a pharmaceutically acceptable salt such as for example the sulfate salt, acetate salt or a phosphate salt.  
25 An example of a unit dosage formulation comprises 5 mg of a compound of the present invention as a pharmaceutically acceptable salt in a 10 mL sterile glass ampoule. Another example of a unit dosage formulation comprises about 10 mg of a compound of the present invention as a pharmaceutically  
30 acceptable salt in 20 mL of isotonic saline contained in a sterile ampoule.

The compounds can be administered by a variety of routes including oral, rectal, transdermal, subcutaneous, intravenous, intramuscular, and intranasal. The compounds

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of the present invention are preferably formulated prior to administration.

The present pharmaceutical compositions are prepared by known procedures using well known and readily available ingredients. The compositions of this invention may be formulated so as to provide quick, sustained, or delayed release of the active ingredient after administration to the patient by employing procedures well known in the art. In making the compositions of the present invention, the active ingredient will usually be admixed with a carrier, or diluted by a carrier, or enclosed within a carrier which may be in the form of a capsule, sachet, paper or other container. When the carrier serves as a diluent, it may be a solid, semi-solid or liquid material which acts as a vehicle, excipient or medium for the active ingredient. Thus, the compositions can be in the form of tablets, pills, powders, lozenges, sachets, cachets, elixirs, suspensions, emulsions, solutions, syrups, aerosols, (as a solid or in a liquid medium), soft and hard gelatin capsules, suppositories, sterile injectable solutions, sterile packaged powders, and the like.

The following formulation examples are illustrative only and are not intended to limit the scope of the invention in any way. "Active ingredient," of course, means a compound according to formula I or a pharmaceutically acceptable salt or solvate thereof.

Formulation 1: Hard gelatin capsules are prepared using the following ingredients:

	Quantity (mg/capsule)
Active ingredient	250
Starch, dried	200
Magnesium stearate	<u>10</u>

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Total 460 mg

Formulation 2: A tablet is prepared using the ingredients below:

	Quantity (mg/tablet)
Active ingredient	250
Cellulose, microcrystalline	400
Silicon dioxide, fumed	10
Stearic acid	5
Total	665 mg

- 5 The components are blended and compressed to form tablets each weighing 665 mg.

Formulation 3: An aerosol solution is prepared containing the following components:

	Weight
Active ingredient	0.25
Ethanol	29.75
Propellant 22 (Chlorodifluoromethane)	70.00
Total	100.00

10

- The active compound is mixed with ethanol and the mixture added to a portion of the propellant 22, cooled to -30 °C and transferred to a filling device. The required amount is then fed to a stainless steel container and diluted with the remainder of the propellant. The valve units are then fitted to the container.
- 15

Formulation 4: Tablets, each containing 60 mg of active ingredient, are made as follows:

20

Active ingredient 60 mg

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Starch	45 mg
Microcrystalline cellulose	35 mg
Polyvinylpyrrolidone (as 10% solution in water)	4 mg
Sodium carboxymethyl starch	4.5 mg
Magnesium stearate	0.5 mg
Talc	<u>1 mg</u>
Total	150 mg

The active ingredient, starch and cellulose are passed through a No. 45 mesh U.S. sieve and mixed thoroughly. The aqueous solution containing polyvinylpyrrolidone is mixed  
5 with the resultant powder, and the mixture then is passed through a No. 14 mesh U.S. sieve. The granules so produced are dried at 50 °C and passed through a No. 18 mesh U.S. Sieve. The sodium carboxymethyl starch, magnesium stearate and talc, previously passed through a No. 60 mesh U.S.  
10 sieve, are then added to the granules which, after mixing, are compressed on a tablet machine to yield tablets each weighing 150 mg.

Formulation 5: Capsules, each containing 80 mg of  
15 active ingredient, are made as follows:

Active ingredient	80 mg
Starch	59 mg
Microcrystalline cellulose	59 mg
Magnesium stearate	<u>2 mg</u>
Total	200 mg

The active ingredient, cellulose, starch, and magnesium stearate are blended, passed through a No. 45 mesh U.S.  
20 sieve, and filled into hard gelatin capsules in 200 mg quantities.

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Formulation 6: Suppositories, each containing 225 mg of active ingredient, are made as follows:

Active ingredient	225 mg
Saturated fatty acid glycerides	<u>2,000 mg</u>
Total	2,225 mg

5

The active ingredient is passed through a No. 60 mesh U.S. sieve and suspended in the saturated fatty acid glycerides previously melted using the minimum heat necessary. The mixture is then poured into a suppository mold of nominal  
10 2 g capacity and allowed to cool.

Formulation 7: Suspensions, each containing 50 mg of active ingredient per 5 mL dose, are made as follows:

Active ingredient	50 mg
Sodium carboxymethyl cellulose	50 mg
Syrup	1.25 mL
Benzoic acid solution	0.10 mL
Flavor	q.v.
Color	q.v.
Purified water to total	5 mL

15

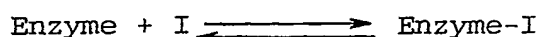
The active ingredient is passed through a No. 45 mesh U.S. sieve and mixed with the sodium carboxymethyl cellulose and syrup to form a smooth paste. The benzoic acid solution, flavor and color are diluted with a portion of the water and  
20 added, with stirring. Sufficient water is then added to produce the required volume.

The ability of a compound of the present invention to be an effective and orally active factor Xa inhibitor may be

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evaluated in one or more of the following assays or in other standard assays known to those in the art.

The inhibition by a compound of the inhibition of a serine protease of the human blood coagulation system or of the fibrinolytic system, as well as of trypsin, is determined in vitro for the particular enzyme by measuring its inhibitor binding affinity in an assay in which the enzyme hydrolyzes a particular chromogenic substrate, for example as described in Smith, G.F.; Gifford-Moore, D.; Craft, T.J.; Chirgadze, N.; Ruterbories, K.J.; Lindstrom, T.D.; Satterwhite, J.H. *Efegatran: A New Cardiovascular Anticoagulant. New Anticoagulants for the Cardiovascular Patient*; Pifarre, R., Ed.; Hanley & Belfus, Inc.: Philadelphia, 1997; pp. 265-300. The inhibitor binding affinity is measured as apparent association constant  $K_{ass}$  which is the hypothetical equilibrium constant for the reaction between enzyme and the test inhibitor compound (I).



$$K_{ass} = \frac{[\text{Enzyme-I}]}{([\text{Enzyme}] \times [\text{I}])}$$

20

Conveniently, enzyme inhibition kinetics are performed in a high-volume protocol using automated dilutions of inhibitors (n=3 for each of four to eight inhibitor concentrations) into 96-well polystyrene plates and reaction rates are determined from the rate of hydrolysis of appropriate p-nitroanilide substrates at 405 nm using a Thermomax plate reader from Molecular Devices (San Francisco, CA). The same general protocol is followed for all enzymes studied: In each well is placed 50  $\mu\text{L}$  buffer (0.06 M Tris, 0.3 M NaCl, pH 7.4), followed by 25  $\mu\text{L}$  of inhibitor solution (in 100% methanol) and 25  $\mu\text{L}$  enzyme solution (e.g., human factor Xa, 32 nM in 0.03 M Tris,

25

30



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0.15 M NaCl, 1 mg/mL HAS); finally, within two minutes, 150  $\mu$ L aqueous solution of chromogenic substrate (e.g., 0.3 mM BzIle-Glu-Gly-Arg-pNA) is added to start the enzymatic reaction. Final factor Xa concentration is 3.2 nM. The rates of chromogenic substrate hydrolysis reactions provide a linear relationship with the enzymes studied such that free enzyme can be quantitated in reaction mixtures. Data is analyzed directly as rates by the Softmax program to produce [free enzyme] calculations for tight-binding Kass determinations. For apparent Kass determinations, human factor Xa is used to hydrolyze BzIle-Glu-Gly-Arg-pNA; 5.9 nM human thrombin is used to hydrolyze 0.2 mM BzPhe-Val-Arg-pNA; 3.4 nM human plasmin is used with 0.5 mM HD-Val-Leu-Lys-pNA; 1.2 nM human nt-PA is used with 0.8 mM HD-Ile-Pro-Arg-pNA; and 0.4 nM urokinase is used with 0.4 mM pyro-Glu-Gly-Arg-pNA.

Kass is calculated for a range of concentrations of test compounds which produce hydrolysis inhibition of between 20% and 80% of control and the mean value reported in units of liter per mole. In general, a factor Xa inhibiting compound of formula I of the instant invention, as exemplified herein, exhibits a Kass of  $10 \times 10^6$  L/mole or much greater.

The factor Xa inhibitor preferably should spare fibrinolysis induced by urokinase, tissue plasminogen activator (t-PA) and streptokinase. This would be important to the therapeutic use of such an agent as an adjunct to streptokinase, tp-PA or urokinase thrombolytic therapy and to the use of such an agent as an endogenous fibrinolysis-sparing (with respect to t-PA and urokinase) antithrombotic agent. In addition to the lack of interference with the amidase activity of the fibrinolytic proteases, such fibrinolytic system sparing can be studied by the use of

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human plasma clots and their lysis by the respective fibrinolytic plasminogen activators.

### Materials

5 Dog plasma is obtained from conscious mixed-breed hounds (either sex Butler Farms, Clyde, New York, U.S.A.) by venipuncture into 3.8 percent citrate. Fibrinogen is prepared from fresh dog plasma and human fibrinogen is prepared from in-date ACD human blood at the fraction I-2  
10 according to previous procedures and specification. Smith, Biochem. J., 185, 1-11 (1980; and Smith, et al., Biochemistry, 11, 2958-2967, (1972). Human fibrinogen (98 percent pure/plasmin free) is from American Diagnostica, Greenwich, Connecticut. Radiolabeling of fibrinogen I-2  
15 preparations is performed as previously reported. Smith, et al., Biochemistry, 11, 2958-2967, (1972). Urokinase is purchased from Leo Pharmaceuticals, Denmark, as 2200 Ploug units/vial. Streptokinase is purchased from Hoechst-Roussel Pharmaceuticals, Somerville, New Jersey.

20

### Methods - Effects on Lysis of Human Plasma Clots by t-PA

Human plasma clots are formed in micro test tubes by adding 50  $\mu$ L thrombin (73 NIH unit/mL) to 100  $\mu$ L human plasma which contains 0.0229  $\mu$ Ci 125-iodine labeled fibrinogen. Clot  
25 lysis is studied by overlaying the clots with 50  $\mu$ L of urokinase or streptokinase (50, 100, or 1000 unit/mL) and incubating for 20 hours at room temperature. After incubation the tubes are centrifuged in a Beckman Microfuge. 25  $\mu$ L of supernate is added into 1.0 mL volume of 0.03 M  
30 tris/0.15 M NaCl buffer for gamma counting. Counting controls 100 percent lysis are obtained by omitting thrombin (and substituting buffer). The factor Xa inhibitors are evaluated for possible interference with fibrinolysis by including the compounds in the overlay solutions at 1, 5,

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and 10 µg/mL concentrations. Rough approximations of IC<sub>50</sub> values are estimated by linear extrapolations from data points to a value which would represent 50 percent of lysis for that particular concentration of fibrinolytic agent.

5

### Anticoagulant Activity

#### Materials

Dog plasma and rat plasma are obtained from conscious mixed-breed hounds (either sex, Butler Farms, Clyde, New York, U.S.A.) or from anesthetized male Sprague-Dawley rats (Harlan Sprague-Dawley, Inc., Indianapolis, Indiana, U.S.A.) by venipuncture into 3.8 percent citrate. Fibrinogen is prepared from in-date ACD human blood as the fraction I-2 according to previous procedures and specifications. Smith, Biochem. J., 185, 1-11 (1980); and Smith, et al., Biochemistry, 11, 2958-2967 (1972). Human fibrinogen is also purchased as 98 percent pure/plasmin free from American Diagnostica, Greenwich, Connecticut. Coagulation reagents Actin, Thromboplastin, Innovin and Human plasma are from Baxter Healthcare Corp., Dade Division, Miami, Florida. Bovine thrombin from Parke-Davis (Detroit, Michigan) is used for coagulation assays in plasma.

15

20

#### Methods

### 25 Anticoagulation Determinations

Coagulation assay procedures are as previously described. Smith, et al., Thrombosis Research, 50, 163-174 (1988). A CoAScreener coagulation instrument (American LABor, Inc.) is used for all coagulation assay measurements. The prothrombin time (PT) is measured by adding 0.05 mL saline and 0.05 mL Thromboplastin-C reagent or recombinant human tissue factor reagent (Innovin) to 0.05 mL test plasma. The activated partial thromboplastin time (APTT) is measured by incubation of 0.05 mL test plasma with 0.05 mL Actin reagent

30

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for 120 seconds followed by 0.05 mL  $\text{CaCl}_2$  (0.02 M). The thrombin time (TT) is measured by adding 0.05 mL saline and 0.05 mL thrombin (10 NIH units/mL) to 0.05 mL test plasma. The compounds of formula I are added to human or animal plasma over a wide range of concentrations to determine prolongation effects on the APTT, PT, and TT assays. Linear extrapolations are performed to estimate the concentrations required to double the clotting time for each assay. Compounds of the instant invention potentially extended the prolongation times in the APTT and PT assays, for example in some cases, with assay concentrations necessary to double the APTT or PT of less than 1  $\mu\text{M}$ .

#### Animals

Male Sprague Dawley rats (350-425 gm, Harlan Sprague Dawley Inc., Indianapolis, IN) are anesthetized with xylazine (20 mg/kg, s.c.) and ketamine (120 mg/kg, s.c.) or preferably are anesthetized using isoflurane anesthesia (2-3%, conveniently 2.5%, for surgery; 1.5-2.5%, conveniently 2.5%, for maintenance; flow rate kept at 0.5% throughout) and maintained on a heated water blanket (37 °C). The jugular vein(s) is cannulated to allow for infusions.

#### Arterio-Venous shunt model

The left jugular vein and right carotid artery are cannulated with 20 cm lengths of polyethylene PE 60 tubing. A 6 cm center section of larger tubing (PE 190) with a cotton thread (5 cm) in the lumen, is friction fitted between the longer sections to complete the arterio-venous shunt circuit. Blood is circulated through the shunt for 15 min before the thread is carefully removed and weighed. The weight of a wet thread is subtracted from the total weight of the thread and thrombus (see J.R. Smith, Br J Pharmacol, 77:29, 1982).

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FeCl<sub>3</sub> model of arterial injury

The carotid arteries are isolated via a midline ventral cervical incision. A thermocouple is placed under each  
5 artery and vessel temperature is recorded continuously on a strip chart recorder. A cuff of tubing (0.058 ID x 0.077 OD x 4 mm, Baxter Med. Grade Silicone), cut longitudinally, is placed around each carotid directly above the thermocouple. FeCl<sub>3</sub> hexahydrate is dissolved in water and the  
10 concentration (20 percent) is expressed in terms of the actual weight of FeCl<sub>3</sub> only. To injure the artery and induce thrombosis, 2.85  $\mu$ L is pipetted into the cuff to bathe the artery above the thermocouple probe. Arterial occlusion is indicated by a rapid drop in temperature. The  
15 time to occlusion is reported in minutes and represents the elapsed time between application of FeCl<sub>3</sub> and the rapid drop in vessel temperature (see K.D. Kurz, Thromb. Res., 60:269, 1990).

20 Ex vivo coagulation parameters

Ex vivo plasma thrombin time (TT), prothrombin time (PT) and activated partial thromboplastin time (APTT) are measured with a fibrometer. Blood is sampled from a jugular catheter and collected in syringe containing sodium citrate (3.8  
25 percent, 1 part to 9 parts blood). To measure TT, rat plasma (0.1 mL) is mixed with isotonic saline (0.1 mL) and bovine thrombin (0.1 mL, 30 U/mL in TRIS buffer; Parke Davis) at 37 °C. For PT, to plasma (0.1 mL) mixed with isotonic saline (0.1 mL) is added PT reagent (0.1 mL, Dade,  
30 Thromboplastin-C); and the fibrometer started immediately after the addition of the final reagent. For APTT, plasma (0.1 mL) and APTT solution (0.1 mL, Organon Teknika) are incubated for 5 minutes (37 °C); and CaCl<sub>2</sub> (0.1 mL, 0.025 M)

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is added to start coagulation. Assays are done in duplicate and averaged.

#### Index of Bioavailability

- 5 Bioavailability studies may be conducted as follows.  
Compounds are administered as aqueous solutions, or as solutions in 5% PEG 200, to male Fisher rats, intravenously (iv) at 5 mg/kg via tail vein injection and orally (po) as aqueous solutions, or as a suspension in 5% acacia, to  
10 fasted animals at 20 mg/kg by gavage. Serial blood samples are obtained at 5, 30, 120, and 240 minutes postdose following intravenous administration and at 1, 2, 4, and 6 hours after oral dosing. Plasma is analyzed for drug concentration using an HPLC procedure involving C8 Bond  
15 Elute (Varian) cartridges for sample preparation and a methanol/30 mM ammonium acetate buffer (pH 4) gradient optimized for each compound. % Oral bioavailability is calculated by the following equation:

20 
$$\% \text{ Oral bioavailability} = \frac{\text{AUC po}}{\text{AUC iv}} \times \frac{\text{Dose iv}}{\text{Dose po}} \times 100$$

where AUC is area under the curve calculated from the plasma level of compound over the time course of the experiment following oral (AUC po) and intravenous (AUC iv) dosing.

25

#### Compounds

- For oral determinations, the compound may be administered orally, by gavage, as a suspension in 5% acacia to conscious fasted rats. The pretreatment time before flow is  
30 established through the shunt is selected based upon the peak apparent plasma concentration recorded in preliminary time course experiments that track apparent drug concentration in plasma following oral administration to

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conscious fasted rats, and typically varies between 1 to 5 hours. Animals used in antithrombotic efficacy experiments are anesthetized as described 15 minutes before the predetermined pretreatment time to allow for surgical preparation of the animals. Compound solutions are prepared fresh daily in normal saline or in 5% PEG200 in water for iv determinations and are injected as a bolus or are infused starting 15 minutes before and continuing throughout the experimental perturbation which is 15 minutes in the arteriovenous shunt model and 60 minutes in the FeCl<sub>3</sub> model of arterial injury and in the spontaneous thrombolysis model. Typically, bolus injection volume is 1 mL/kg for iv, and 5 mL/kg for po, and infusion volume is 3 mL/h. For a similar procedure run in the anesthetized rabbit, for example an infusion rate of 6.8 mL/h was used for one compound infused in 5% PEG200 in water.

#### Statistics

Results are expressed as means +/- SEM. One-way analysis of variance is used to detect statistically significant differences and then Dunnett's test is applied to determine which means are different. Significance level for rejection of the null hypothesis of equal means is  $P < 0.05$ .

#### Animals

Male dogs (Beagles; 18 months - 2 years; 12-13 kg, Marshall Farms, North Rose, New York 14516) are fasted overnight and fed Purina certified Prescription Diet (Purina Mills, St. Louis, Missouri) 240 minutes after dosing. Water is available *ad libitum*. The room temperature is maintained between 66-74 °F; 45-50 percent relative humidity; and lighted from 0600-1800 hours.

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Pharmacokinetic model.

Test compound is formulated immediately prior to dosing by making a suspension in a "wet granulation" (povidone, 0.85 mg/mL; lactose, 15.0 mg/mL; and polysorbate 80, 65  $\mu$ L in 250 mL water). Dogs are given a single 20 mg/kg (in 25 mL of wet granulation) dose of test compound by oral gavage. Blood samples (4.5 mL) are taken from the cephalic vein at 0.25, 0.5, 0.75, 1, 2, 3, 4 and 6 hours after dosing. Samples are collected in citrated Vacutainer tubes and kept on ice prior to reduction to plasma by centrifugation. Plasma samples are analyzed by HPLC MS. Plasma concentration of test compound is recorded and used to calculate the pharmacokinetic parameters: elimination rate constant,  $K_e$ ; total clearance,  $Cl_t$ ; volume of distribution,  $V_d$ ; time of maximum plasma test compound concentration,  $T_{max}$ ; maximum concentration of test compound of  $T_{max}$ ,  $C_{max}$ ; plasma half-life,  $t_{0.5}$ ; and area under the curve, A.U.C.; fraction of test compound absorbed,  $F$ .

20 Canine Model of Coronary Artery Thrombosis

Male dogs (Beagles, as described above) are fasted overnight and dosed with test compound that is formulated immediately prior to dosing by making a suspension in a "wet granulation" as described above. Dogs are given a single dose of 5, 10 or 20 mg/kg (in 25 mL of wet granulation) of test compound by oral gavage. Based on the pharmacokinetics of the test compound, dogs are dosed either 1 or 2 hours prior to anesthesia. Dogs are anesthetized with sodium pentobarbital (30 mg/kg intravenously, i.v.), intubated, and ventilated with room air. Tidal volume and respiratory rates are adjusted to maintain blood  $PO_2$ ,  $PCO_2$ , and pH within normal limits. Subdermal needle electrodes are inserted for the recording of a lead II ECG.



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The left jugular vein and common carotid artery are isolated through a left mediolateral neck incision. Arterial blood pressure (ABP) is measured continuously with a precalibrated Millar transducer (model MPC-500, Millar Instruments, Houston, TX, U.S.A.) inserted into the carotid artery. The jugular vein is cannulated for blood sampling during the experiment. In addition, the femoral veins of both hindlegs are cannulated for administration of test compound.

10 A left thoracotomy is performed at the fifth intercostal space, and the heart is suspended in a pericardial cradle. A 1- to 2-cm segment of the left circumflex coronary artery (LCX) is isolated proximal to the first major diagonal ventricular branch. A 26-gauge needle-  
15 tipped wire anodal electrode (Teflon-coated, 30-gauge silverplated copper wire) 3-4 mm long is inserted into the LCX and placed in contact with the intimal surface of the artery (confirmed at the end of the experiment). The stimulating circuit is completed by placing the cathode in a  
20 subcutaneous (s.c.) site. An adjustable plastic occluder is placed around the LCX, over the region of the electrode. A precalibrated electromagnetic flow probe (Carolina Medical Electronics, King, NC, U.S.A.) is placed around the LCX proximal to the anode for measurement of coronary blood flow  
25 (CBF). The occluder is adjusted to produce a 40-50 percent inhibition of the hyperemic blood flow response observed after 10-s mechanical occlusion of the LCX. All hemodynamic and ECG measurements are recorded and analyzed with a data acquisition system (Notochord HEM data analysis system,  
30 Croissy, France).

#### Thrombus Formation and Compound Administration Regimens

Electrolytic injury of the intima of the LCX is produced by applying 100- $\mu$ A direct current (DC) to the

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anode. The current is maintained for 60 min and then discontinued whether the vessel has occluded or not. Thrombus formation proceeds spontaneously until the LCX is totally occluded (determined as zero CBF and an increase in the S-T segment for a minimum of 30 minutes). The preparation is followed for 4 hours at which time the animal is euthanized and the thrombus is dissected from the LCX and weighed.

10 Hematology, coagulation and template bleeding time determinations

Citrated blood (3 mL, 1 part 3.8% citrate : 9 parts blood) is drawn before drug administration, at 60 min after administration, at 60 min after initiation of vessel injury and just prior to the end of the experiment. Whole blood cell counts, hemoglobin, and hematocrit values are determined on a 40- $\mu$ L sample of the citrated whole blood with a hematology analyzer (Cell-Dyn 900, Sequoia-Turner, Mount View, CA, U.S.A.). The remaining blood was centrifuged at 3,000 g for 5 min to prepare cell-free plasma. Plasma clotting times, prothrombin time (PT) and activated partial thromoplastin times (APTT) were performed using standard Dade reagents and the Coa-Screener coagulation device (American Labor, Largo, FL). Gingival template bleeding times are determined with a Simplate II bleeding time device (Organon Teknika Durham, N.C., U.S.A.). The device is used to make 2 horizontal incisions in the gingiva of either the upper or lower left jaw of the dog. Each incision is 3 mm wide x 2 mm deep. The incisions are made, and a stopwatch is used to determine how long bleeding occurs. A cotton swab is used to soak up the blood as it oozes from the incision. Template bleeding time is the time from incision to stoppage of bleeding. Bleeding times are taken just before administration of test compound (0 min), 60 min into

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infusion, at conclusion of administration of the test compound (120 min), and at the end of the experiment.

All data are analyzed by one-way analysis of variance (ANOVA) followed by Dunnet's post hoc *t* test to determine the level of significance. Repeated-measures ANOVA are used to determine significant differences between time points during the experiments. Values are determined to be statistically different at least at the level of  $p < 0.05$ . All values are mean  $\pm$  SEM. All studies are conducted in accordance with the guiding principles of the American Physiological Society. Further details regarding the procedures are described in Jackson, et al., J. Cardiovasc. Pharmacol., (1993), 21, 587-599.

Compounds of the instant invention are potent anticoagulant and antithrombotic agents which exhibit particularly good plasma exposure following oral administration, as well as desirable volume of distribution and tissue selectivity properties, as evidenced by standard pharmacokinetic/pharmacodynamic and brain flux assays.

The following Examples are provided to further describe the invention and are not to be construed as limitations thereof.

The abbreviations, symbols and terms used in the examples have the following meanings.

Ac = acetyl  
Analysis = elemental analysis  
aq = aqueous  
Boc = t-butyloxycarbonyl  
Calcd = calculated  
conc = concentrated  
DMF = dimethylformamide  
DMSO = dimethylsulfoxide  
EtOAc = ethyl acetate  
EtOH = ethanol

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MeOH = methanol

HPLC = High Performance Liquid Chromatography

IR = Infrared Spectrum

APCI-MS = atmospheric pressure chemical ionization

5 mass spectrum

ESI-MS (or ES-MS) = electrospray ionization mass spectrum

FD-MS = field desorption mass spectrum

IS-MS = ion spray mass spectrum

10 NMR = Nuclear Magnetic Resonance

RPHPLC = Reversed Phase High Performance Liquid Chromatography

RT (or  $R_t$ ) = retention time

satd = saturated

15 SCX = strong cation exchange (resin)

TFA = trifluoroacetic acid

THF = tetrahydrofuran

Unless otherwise stated, pH adjustments and work up are with aqueous acid or base solutions.  $^1\text{H}$ -NMR indicates a  
20 satisfactory proton NMR spectrum was obtained for the compound described. IR indicates a satisfactory infra red spectrum was obtained for the compound described.

Analytical HPLC method was a linear gradient of 90/10 to 50/50 (0.1% TFA in water/0.1% TFA in acetonitrile) over  
25 40 minutes with a flow rate of 1 mL/min.

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**Preparation of Nitro-Amide (NA) Intermediates****General Procedure NA-A:****2-Nitro-N-(5-methylpyridin-2-yl)benzamide.**

5 To a stirring solution of 2-amino-5-methylpyridine (3.1 g, 29 mmol) in dichloromethane (200 mL) was added pyridine (7.3 mL, 90 mmol) followed by 2-nitrobenzoyl chloride (5.7 g, 30 mmol). After 4 h, the solvent was removed in vacuo and the residue was partitioned between  
10 ethyl acetate (500 mL) and water (250 mL). The organic phase was separated and washed with water, brine, dried (MgSO<sub>4</sub>) and filtered, and then concentrated in vacuo to a volume of about 100 mL (precipitate observed). The mixture was then sonicated and allowed to stand overnight then  
15 filtered. The collected solid was then washed with diethyl ether, filtered and dried under vacuum to give 3.9 g (52%) of the title compound.

<sup>1</sup>H-NMR

20 FD-MS, m/e 256.9 (M+).

Analysis for C<sub>13</sub>H<sub>11</sub>N<sub>3</sub>O<sub>3</sub>:

Calc: C, 60.70; H, 4.31; N, 16.33;

Found: C, 61.21; H, 4.32; N, 16.63.

25 **General Procedure NA-B:****4-Chloro-N-(5-chloropyridin-2-yl)-2-nitrobenzamide.**

To a stirring suspension of 4-chloro-2-nitrobenzoic acid (20 g, 99 mmol) in dichloromethane (500 mL) was added a few drops of DMF, followed by oxalyl chloride (15.1 g, 119  
30 mmol). After 1 h, the solvent was removed in vacuo and the residue was dissolved in dichloromethane (500 mL). To this stirring solution was added pyridine (24 mL, 297 mmol) followed by 2-amino-5-chloropyridine (12.7 g, 99 mmol). After stirring overnight, the solvents were removed in vacuo

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and the residue was stirred vigorously with ethyl acetate and water for several hours. The mixture was filtered to give a white solid, which was washed with ethyl acetate and dried in vacuo to give 23 g (74%) of the title compound.

- 5 The combined ethyl acetate washings and extract were then washed twice with 1 M citric acid, once with brine, twice with saturated aq sodium bicarbonate, and again with brine. The organic phase was then dried with  $\text{MgSO}_4$ , filtered and concentrated in vacuo. The solid was then suspended in  
10 diethyl ether, sonicated and filtered to give a second crop of the title compound as a white solid (5.79 g, 19%).

$^1\text{H}$ -NMR

IS-MS, m/e 312.0 (M+1)

- 15 Analysis for  $\text{C}_{12}\text{H}_7\text{N}_3\text{O}_3\text{Cl}_2$ :

Calcd: C, 46.18; H, 2.26; N, 13.46;

Found: C, 46.24; H, 2.37; N, 13.43.

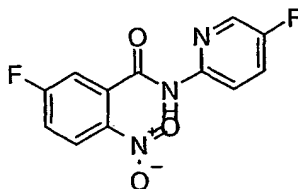
#### Preparation of Intermediates NA-1 - NA-12

- 20 The following exemplary nitro-amide intermediates were prepared using a conventional procedure such as that of General Procedure NA-A or General Procedure NA-B, or as otherwise described.

25

#### Intermediate NA-1

5-Fluoro-2-nitro-N-(5-fluoropyridin-2-yl)benzamide.



$^1\text{H}$ -NMR

ESI-MS, m/e 278.09 (M-1).

30

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The starting 5-fluoro-2-nitrobenzoic acid is prepared from 5-fluoro-2-nitrotoluene using a procedure similar to that for the preparation of 4-fluoro-2-nitrobenzoic acid which follows:

- 5 To a stirring solution of  $\text{KMnO}_4$  (76 g, 483 mmol) in water (1 L) was added 4-fluoro-2-nitrotoluene and the solution was heated to reflux. After 4 h, the hot mixture was filtered and the filtrate was cooled with ice, washed with diethyl ether, acidified with conc HCl, and then
- 10 extracted twice with diethyl ether. The combined ether extracts were washed with brine, dried with  $\text{MgSO}_4$ , filtered and concentrated in vacuo to give 12.07 g (34%) of a white solid.

15  $^1\text{H-NMR}$

IS-MS, m/e 184.0 (M-1).

Analysis for  $\text{C}_7\text{H}_4\text{NO}_4\text{F}$ :

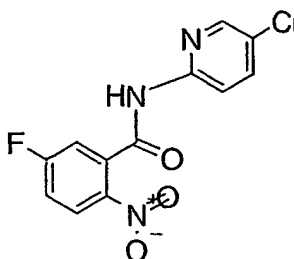
Calcd: C, 45.42; H, 2.18; N, 7.57;

Found: C, 45.63; H, 2.30; N, 7.61.

20

#### Intermediate NA-2

5-Fluoro-2-nitro-N-(5-chloropyridin-2-yl)benzamide.



$^1\text{H-NMR}$

25 ESI-MS, m/e 296.22 (M+1).

Analysis for  $\text{C}_{12}\text{H}_7\text{ClFN}_3\text{O}_3$ :

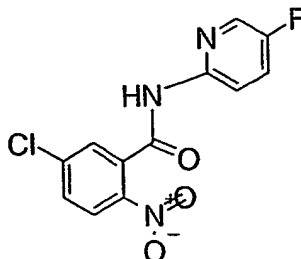
Calcd: C, 48.75; H, 2.39; N, 14.21;

Found: C, 48.57; H, 2.37; N, 14.19.

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## Intermediate NA-3

5-Chloro-2-nitro-N-(5-fluoropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

5 ESI-MS, m/e 296.24 (M+1).

Analysis for C<sub>12</sub>H<sub>7</sub>ClFN<sub>3</sub>O<sub>3</sub>:

Calcd: C, 48.75; H, 2.39; N, 14.21;

Found: C, 48.97; H, 2.61; N, 14.13.

10 <sup>1</sup>H-NMR

IS-MS, m/e 184.0 (M-1).

Analysis for C<sub>7</sub>H<sub>4</sub>NO<sub>4</sub>F:

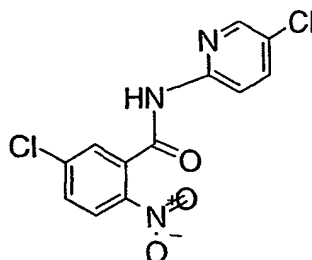
Calcd: C, 45.42; H, 2.18; N, 7.57;

Found: C, 45.63; H, 2.30; N, 7.61.

15

## Intermediate NA-4

5-Chloro-2-nitro-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

20 ESI-MS, m/e 311.96 (M+1).

Analysis for C<sub>12</sub>H<sub>7</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>:

Calcd: C, 46.18; H, 2.26; N, 13.46;

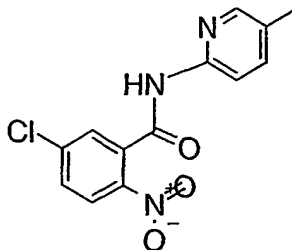
Found: C, 46.24; H, 2.22; N, 13.29.



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## Intermediate NA-5

5-Chloro-2-nitro-N-(5-methylpyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

5 ESI-MS, m/e 291.97 (M+1).

Analysis for C<sub>13</sub>H<sub>10</sub>ClN<sub>3</sub>O<sub>3</sub>:

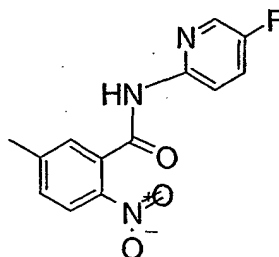
Calcd: C, 53.53; H, 3.46; N, 14.41;

Found: C, 53.76; H, 3.41; N, 14.35.

10

## Intermediate NA-6

5-Methyl-2-nitro-N-(5-fluoropyridin-2-yl)benzamide.

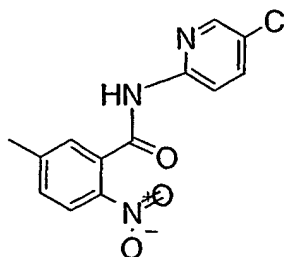
<sup>1</sup>H-NMR

APCI-MS, m/e 276 (M+1).

15

## Intermediate NA-7

5-Methyl-2-nitro-N-(5-chloropyridin-2-yl)benzamide.



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<sup>1</sup>H-NMR

ESI-MS, m/e 292 (M+1).

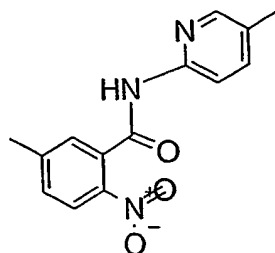
Analysis for C<sub>13</sub>H<sub>10</sub>ClN<sub>3</sub>O<sub>3</sub>:

Calcd: C, 53.53; H, 3.46; N, 14.41;

5 Found: C, 53.52; H, 3.56; N, 14.49.

## Intermediate NA-8

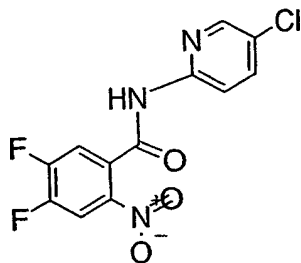
5-Methyl-2-nitro-N-(5-methylpyridin-2-yl)benzamide.

10 <sup>1</sup>H-NMR

ESI-MS, m/e 272.37 (M+1).

## Intermediate NA-9

4,5-Difluoro-2-nitro-N-(5-chloropyridin-2-yl)benzamide.



15

<sup>1</sup>H-NMR

ESI-MS, m/e 313.95 (M+1).

Analysis for C<sub>12</sub>H<sub>6</sub>ClF<sub>2</sub>N<sub>3</sub>O<sub>3</sub>:

Calcd: C, 45.95; H, 1.93; N, 13.40;

20 Found: C, 45.77; H, 2.00; N, 13.43.

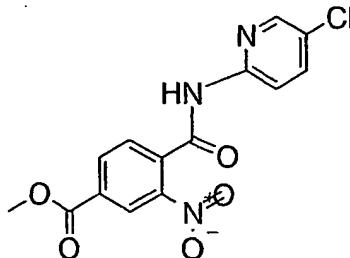
## Intermediate NA-10

[Compound AA-10 prepared via 4-amino-3-iodoacetophenone.]

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## Intermediate NA-11

4-Methoxycarbonyl-2-nitro-N-(5-chloropyridin-2-yl)benzamide.

5  $^1\text{H}$ -NMR

ESI-MS, m/e 336.09 (M+1).

Analysis for  $\text{C}_{14}\text{H}_{10}\text{ClN}_3\text{O}_5$ :

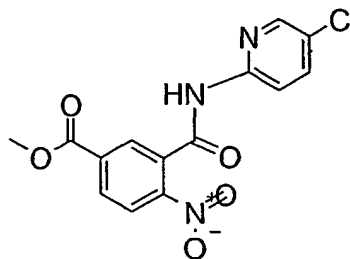
Calcd: C, 50.09; H, 3.00; N, 12.52;

Found: C, 49.83; H, 3.08; N, 12.25.

10

## Intermediate NA-12

5-Methoxycarbonyl-2-nitro-N-(5-chloropyridin-2-yl)benzamide.

 $^1\text{H}$ -NMR

15 ESI-MS, m/e 336.07 (M+1).

Analysis for  $\text{C}_{14}\text{H}_{10}\text{ClN}_3\text{O}_5$ :

Calcd: C, 50.09; H, 3.00; N, 12.52;

Found: C, 50.37; H, 3.08; N, 12.52.

20

## Preparation of Amino-Amide (AA) Intermediates

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**General Procedure AA-A:****N-(5-Methylpyridin-2-yl)-2-aminobenzamide.**

To a stirring solution of N-(5-methylpyridin-2-yl)-2-nitrobenzamide (1.5 g, 5.8 mmol) and Ni(OAc)<sub>2</sub>·4H<sub>2</sub>O (2.9 g, 11.7 mmol) in THF (20 mL) and methanol (40 mL) at 0 °C was added, in small portions, sodium borohydride (0.88 g, 23.2 mmol). After complete addition and an additional 5 min, the solvent was evaporated in vacuo and the residue was partitioned between ethyl acetate (200 mL) and 50% conc NH<sub>4</sub>OH (200 mL). The organic phase was separated and washed again with 50% conc NH<sub>4</sub>OH, followed by brine, then dried with MgSO<sub>4</sub>, filtered and concentrated in vacuo to give 1.25 g (95%) of a light yellow solid.

15 <sup>1</sup>H-NMR

FD-MS, m/e 227.1 (M+).

**General Procedure AA-B:****N-(5-Chloropyridin-2-yl)-2-aminobenzamide.**

To a solution of N-(5-chloropyridin-2-yl)-2-nitrobenzamide (2 g, 7.2 mmol) in THF (50 mL) and ethyl acetate (50 mL) was added Raney Ni (0.2 g) and the mixture was placed under hydrogen (4.1 bar) in a high pressure apparatus. After shaking overnight, the mixture was filtered and concentrated in vacuo and purified by flash chromatography to give 1.5 g (83%) of an off-white solid.

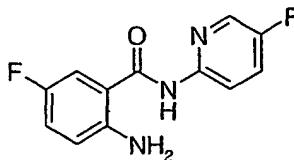
15 <sup>1</sup>H-NMR30 **Preparation of Intermediates AA-1 - AA-14**

The following exemplary amino-amide intermediates were prepared using a conventional procedure such as that of General Procedure AA-A or General Procedure AA-B, or as otherwise described.

-52-

## Intermediate AA-1

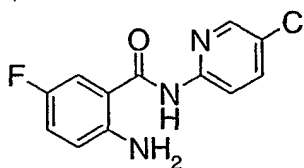
2-Amino-5-fluoro-N-(5-fluoropyridin-2-yl)benzamide.

5  $^1\text{H-NMR}$ 

ESI-MS, m/e 248 (M-1)

## Intermediate AA-2

2-Amino-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.



10

 $^1\text{H-NMR}$ 

ESI-MS, m/e 264.17 (M-1).

Analysis for  $\text{C}_{12}\text{H}_9\text{ClFN}_3\text{O}$ :

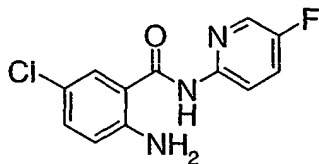
Calcd: C, 54.25; H, 3.41; N, 15.82;

15

Found: C, 53.96; H, 3.43; N, 15.54.

## Intermediate AA-3

2-Amino-5-chloro-N-(5-fluoropyridin-2-yl)benzamide.

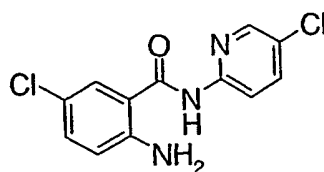
20  $^1\text{H-NMR}$ 

ESI-MS, m/e 264.13 (M-1).

## Intermediate AA-4

2-Amino-5-chloro-N-(5-chloropyridin-2-yl)benzamide.

-53-

<sup>1</sup>H-NMR

ESI-MS, m/e 281.12 (M-1).

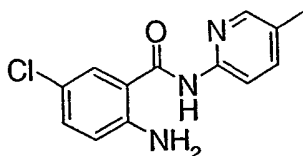
5 Analysis for C<sub>12</sub>H<sub>9</sub>Cl<sub>2</sub>N<sub>3</sub>O:

Calcd: C, 51.09; H, 3.22; N, 14.89;

Found: C, 51.19; H, 3.33; N, 14.61.

**Intermediate AA-5**

10 2-Amino-5-chloro-N-(5-methylpyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

ESI-MS, m/e 260.02 (M-1).

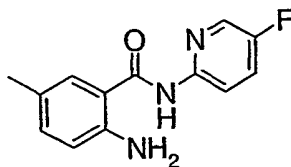
Analysis for C<sub>13</sub>H<sub>12</sub>ClN<sub>3</sub>O:

15 Calcd: C, 59.66; H, 4.62; N, 16.06;

Found: C, 59.89; H, 4.57; N, 15.99.

**Intermediate AA-6**

2-Amino-5-methyl-N-(5-fluoropyridin-2-yl)benzamide.



20

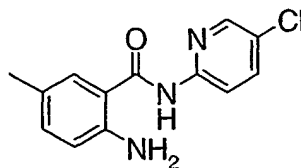
<sup>1</sup>H-NMR

ESI-MS, m/e 244.41 (M-1).

**Intermediate AA-7**

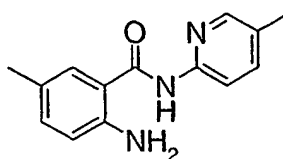
25 2-Amino-5-methyl-N-(5-chloropyridin-2-yl)benzamide.

-54-

<sup>1</sup>H-NMR

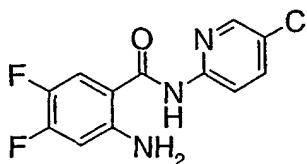
ESI-MS, m/e 260.01 (M-1).

5

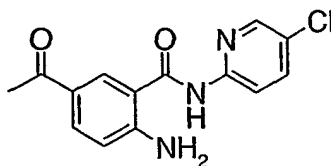
**Intermediate AA-8****2-Amino-5-methyl-N-(5-methylpyridin-2-yl)benzamide.**<sup>1</sup>H-NMR

ESI-MS, m/e 240.15 (M-1).

10

**Intermediate AA-9****2-Amino-4,5-difluoro-N-(5-chloropyridin-2-yl)benzamide.**<sup>1</sup>H-NMR

15 ESI-MS, m/e 282.12 (M-1).

**Intermediate AA-10****5-Acetyl-2-amino-N-(5-chloropyridin-2-yl)benzamide.**

20

To a stirred solution of 4-aminoacetophenone (50 g, 370 mmol) in ethanol (1 L) and dichloromethane (750 mL) at 0 °C was added iodine (94 g, 370 mmol) and silver sulfate (116 g,

-55-

370 mmol). The reaction mixture was stirred at 0 °C for 10 min and then at room temperature for 4 h, filtered and concentrated. The resulting residue was partitioned between dichloromethane and 5 N sodium hydroxide. The organic phase  
5 was dried (magnesium sulfate), filtered, and concentrated in vacuo. The crude product was chromatographed over silica gel, eluting with a stepwise gradient from dichloromethane to 10% ethyl acetate in dichloromethane, to give 38.2 g (40%) of 4-amino-3-iodoacetophenone as a yellow oil.

10 A mixture of 4-amino-3-iodoacetophenone (5.0 g, 19.2 mmol), 2-amino-5-chloropyridine (7.4 g, 54.5 mmol), palladium acetate (431 mg, 1.92 mmol), 1,3-bis(diphenylphosphino)propane (2.37 g, 5.75 mmol), triethylamine (5.4 mL, 38.3 mmol) in acetonitrile (100 mL) was shaken under a  
15 carbon monoxide atmosphere (54.4 bar) for 16 h. The crude mixture was filtered through diatomaceous earth, and the filtrate was stripped to near dryness and titrated with ethyl ether to remove the excess 2-amino-5-chloropyridine. The product was isolated by SCX column, then flash  
20 chromatography using 10% acetonitrile in chloroform. This afforded 1.17 g (21%) of the title product.

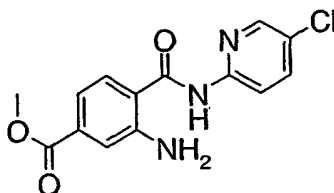
<sup>1</sup>H-NMR

ESI-MS, m/e 288.1 (M-1).

25

#### Intermediate AA-11

2-Amino-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.



<sup>1</sup>H-NMR

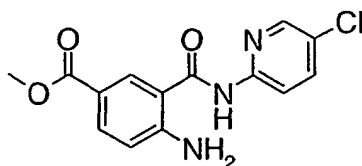
30 ESI-MS, m/e 304.09 (M-1).



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## Intermediate AA-12

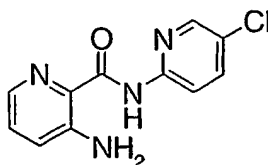
2-Amino-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

5  $^1\text{H-NMR}$ 

ESI-MS, m/e 304 (M-1).

## Intermediate AA-13

3-Amino-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.



10

 $^1\text{H-NMR}$ 

ESI-MS, m/e 247.19 (M-1).

15 The amine was prepared using a similar procedure to the following:

A (Parr) pressure apparatus was charged with 3-amino-2-chloropyridine (500 mg, 3.89 mmol), 2-amino-5-chloropyridine (1.00 g, 7.78 mmol), palladium acetate (88 mg, 0.39 mmol), 1,3-bis(diphenylphosphino)propane (483 mg, 1.17 mmol) and  
20 triethylamine (590 mg, 5.84 mmol). The mixture was placed under a carbon monoxide atmosphere (4.1 bar) and heated at 100 °C. After 72 h, the mixture was filtered, concentrated and the residue purified by column chromatography (SiO<sub>2</sub>: 0 to 5% EtOAc in methylene chloride) affording 550 mg (57%) of  
25 the title compound.

 $^1\text{H-NMR}$ , IR

IS-MS, m/e 249 (M+1).

-57-

Analysis for  $C_{11}H_9ClN_4O$ :

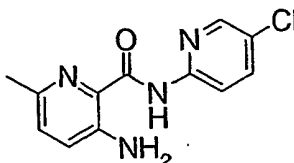
Calcd: C, 53.13; H, 3.65; N, 22.53;

Found: C, 53.40; H, 3.66; N, 22.45.

5

**Intermediate AA-14**

**3-Amino-N-(5-chloropyridin-2-yl)-6-methylpyridine-2-carboxamide.**



Using methods substantially equivalent to those described above for Intermediate AA-13, 3-amino-N-(5-chloropyridin-2-yl)-6-methylpyridine-2-carboxamide (16 g, 46%) was prepared from 3-amino-2-chloro-6-methylpyridine and 2-amino-5-chloropyridine.

 $^1H$  NMR

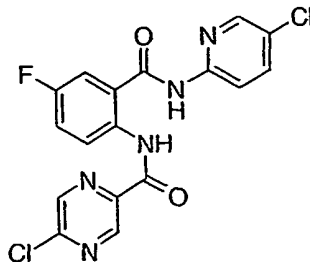
ESI-MS, m/e 263.1 (M+1).

**Preparation of Intermediates A-1 - A-12**

The following intermediates were prepared by acylation of the requisite amine using 5-chloropyrazine-2-carbonyl chloride and a procedure similar to that described for the preparation of Intermediate A-1, or as otherwise described.

**Intermediate A-1**

**2-(5-Chloropyrazin-2-ylcarbonylamino)-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.**



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To a stirred mixture of thionyl chloride (75 mL),  
toluene (25 mL) and DMF (0.2 mL) was added 5-hydroxy-  
pyrazine-2-carboxylic acid (8 g, 57 mmol). The mixture was  
5 heated at 80 °C for 3.5 h. Evaporation of the solvent under  
vacuum provided the solid acid chloride which was dissolved  
in methylene chloride (100 mL).

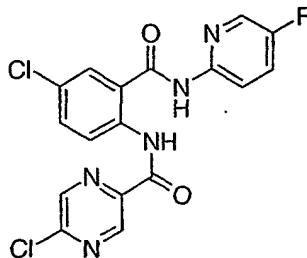
To a cooled (0 °C) suspension of 2-amino-5-fluoro-  
N-(5-chloropyridin-2-yl)benzamide (13.815 g, 52 mmol) in  
10 methylene chloride (200 mL) and pyridine (5.86 g, 6 mL, 74  
mmol) was added dropwise the solution of acid chloride from  
step 1 above over a period of 15-30 min. The reaction  
mixture was stirred at room temperature overnight. Water  
(100 mL) was added, and the mixture stirred 30 min before  
15 the solids were filtered. The solids were washed with water  
(100 mL) and dried under vacuum. The solids were slurried  
in ether (100 mL), sonicated for 15 min, filtered and dried.  
Yield = 19.6 g.

20 <sup>1</sup>H-NMR (DMSO) δ 9.13 (d, J = 1.1 Hz), 8.97 (d, J = 1.1 Hz),  
8.55 (dd, J = 9.1 Hz, and 5.1 Hz), 8.47 (d, J = 2.6 Hz),  
8.11 (d, J = 8.8 Hz), 8.01 (dd, J = 9.1 Hz, and 2.6 Hz),  
7.82 (dd, J = 9.5 Hz, and 2.9 Hz) 7.5 - 7.6 (m).  
ESI-MS, m/e 406.3 (M+1).

25

#### Intermediate A-2

**5-Chloro-2-(5-chloropyrazin-2-ylcarbonylamino)-N-(5-fluoro-  
pyridin-2-yl)benzamide.**



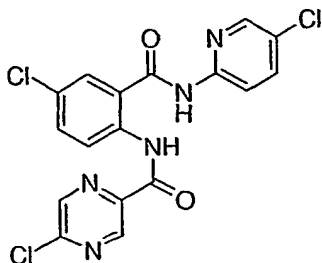
-59-

 $^1\text{H}$ -NMR

ESI-MS, m/e 404.1 (M-1).

## Intermediate A-3

- 5 **5-Chloro-2-[5-chloropyrazin-2-ylcarbonylamino]-N-(5-chloro-pyridin-2-yl)benzamide.**



- $^1\text{H}$ -NMR ( $\text{CDCl}_3$ )  $\delta$  9.25 (d,  $J = 1.1$  Hz), 8.83 (d,  $J = 9.1$  Hz),  
8.71 (d,  $J = 1.1$  Hz), 8.62 (br, s), 8.23 - 8.30 (m), 7.8 -  
10 7.72 (m), 7.59 (dd,  $J = 8.8$  Hz and 2.6 Hz).

FIA-MS, m/e 423.49 (M+1).

Analysis for  $\text{C}_{17}\text{H}_{10}\text{Cl}_3\text{N}_5\text{O}_2$ :

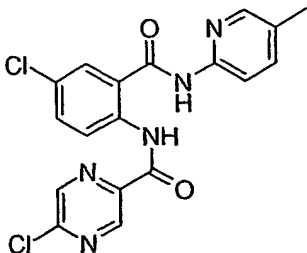
Calcd: C, 48.31; H, 2.38; N, 16.57;

Found: C, 47.87; H, 2.31; N, 16.39.

15

## Intermediate A-4

- 5-Chloro-2-[5-chloropyrazin-2-ylcarbonylamino]-N-(5-methyl-pyridin-2-yl)benzamide.**



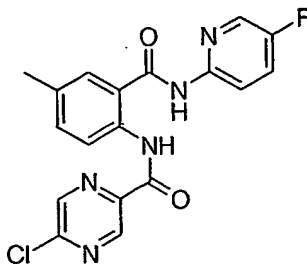
- 20  $^1\text{H}$ -NMR ( $\text{DMSO}$ )  $\delta$  9.13 (d,  $J = 1.1$  Hz), 8.98 (d,  $J = 1.1$  Hz),  
8.62 (d,  $J = 8.8$  Hz), 8.25 (br, s), 8.03 (d,  $J = 2.6$  Hz),  
7.96 (d,  $J = 8.4$  Hz), 7.71 (dd,  $J = 10.5$  Hz and 2.2 Hz),  
2.30 (s).

ESI-MS, m/e 402.17 (M+1).

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## Intermediate A-5

2-[5-Chloropyrazin-2-ylcarbonylamino]-5-methyl-N-(5-fluoropyridin-2-yl)benzamide.



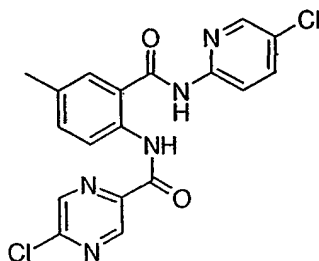
5

 $^1\text{H-NMR}$ 

ESI-MS, m/e 384.1 (M-1).

## Intermediate A-6

10 2-(5-Chloropyrazin-2-ylcarbonylamino)-5-methyl-N-(5-chloropyridin-2-yl)benzamide.



$^1\text{H-NMR}$  (DMSO)  $\delta$  9.12 (d,  $J = 1.5$  Hz), 8.97 (d,  $J = 1.5$  Hz), 8.29 - 8.46 (m), 8.12 (d,  $J = 8.4$  Hz), 8.00 (dd,  $J = 9.1$  Hz and 2.6 Hz), 7.82 (d,  $J = 1.5$  Hz), 7.46 (dd,  $J = 8.4$  Hz and 1.8 Hz), 2.36 (s).

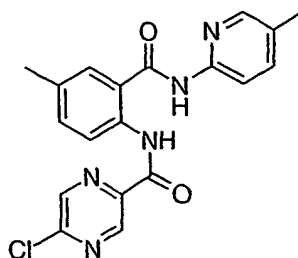
15

ESI-MS, m/e 402.2 (M+1).

## Intermediate A-7

20 2-(5-Chloropyrazin-2-ylcarbonylamino)-5-methyl-N-(5-methylpyridin-2-yl)benzamide.

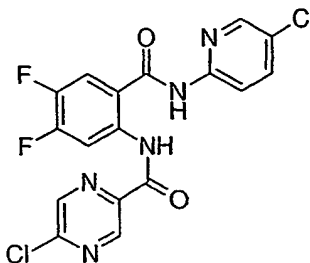
-61-



$^1\text{H-NMR}$  (DMSO)  $\delta$  9.14 (d,  $J = 1.5$  Hz), 8.99 (d,  $J = 1.2$ ),  
 8.51 (d,  $J = 8.5$  Hz), 8.25 (d, br,  $J = 1.5$ ), 8.00 (d,  $J =$   
 8.2 Hz), 7.84 (d,  $J = 1.5$  Hz), 7.71 (dd,  $J = 9.4$  Hz and 2.1  
 5 Hz), 7.46 (dd,  $J = 10$  Hz and 1.4 Hz), 2.37 (s), 2.31 (s).  
 ESI-MS,  $m/e$  380.33 ( $M-1$ ).

#### Intermediate A-8

2-(5-Chloropyrazin-2-ylcarbonylamino)-4,5-difluoro-  
 10 N-(5-chloropyridin-2-yl)benzamide.



$^1\text{H-NMR}$  (DMSO)  $\delta$  9.14 (d,  $J = 1.5$  Hz), 8.98 (d,  $J = 1.1$  Hz),  
 8.59 - 8.66 (m), 8.48 (d,  $J = 2.6$  Hz), 8.08 - 8.19 (m), 8.01  
 (dd,  $J = 9.0$  Hz and 2.4 Hz).  
 15 ESI-MS,  $m/e$  424.04 ( $M+1$ ).

Analysis for  $\text{C}_{17}\text{H}_9\text{Cl}_2\text{F}_2\text{N}_5\text{O}_2$ :

Calcd: C, 48.14; H, 2.14; N, 16.51;

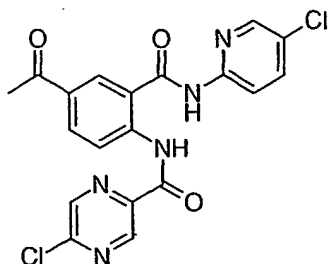
Found: C, 47.65; H, 2.26; N, 16.04.

20

#### Intermediate A-9

5-Acetyl-2-(5-chloropyrazin-2-ylcarbonylamino)-N-(5-methyl-  
 pyridin-2-yl)benzamide.

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$^1\text{H-NMR}$  (DMSO)  $\delta$  9.16 (d,  $J = 1.3$  Hz), 9.00 (d,  $J = 1.3$  Hz),  
8.76 (d,  $J = 8.8$  Hz), 8.54 (d,  $J = 2.0$  Hz), 8.50 (d,  $J = 2.0$   
5 Hz), 8.12 - 8.23 (m), 8.03 (dd,  $J = 8.9$  Hz and 2.6 Hz), 2.66  
(s).

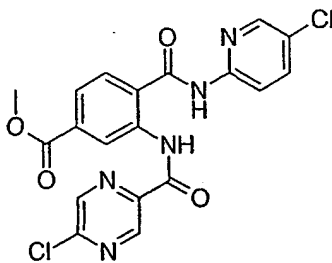
ESI-MS,  $m/e$  430.18 ( $M+1$ ).

Analysis for  $\text{C}_{19}\text{H}_{13}\text{Cl}_2\text{N}_5\text{O}_3$ :

Calcd: C, 53.04; H, 3.04; N, 16.28;  
10 Found: C, 53.07; H, 3.07; N, 15.96.

#### Intermediate A-10

2-(5-Chloropyrazin-2-ylcarbonylamino)-4-methoxycarbonyl-  
N-(5-chloropyridin-2-yl)benzamide.



15

$^1\text{H-NMR}$  (DMSO)  $\delta$  9.16 (dd,  $J = 3.7$  Hz and 1.5 Hz), 8.98 (d,  $J$   
 $= 1.5$  Hz), 8.48 (d,  $J = 2.2$  Hz), 8.01 - 8.15 (m), 7.82 (dd,  
 $J = 8.1$  Hz and 1.6 Hz), 3.39 (s).

ESI-MS,  $m/e$  446.08 ( $M+1$ ).

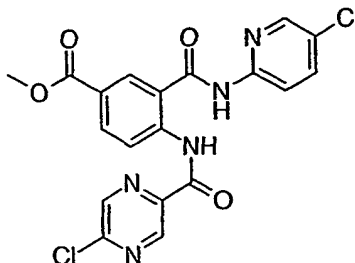
20 Analysis for  $\text{C}_{19}\text{H}_{13}\text{Cl}_2\text{N}_5\text{O}_4$ :

Calcd: C, 51.14; H, 2.94; N, 15.69;  
Found: C, 50.83; H, 2.89; N, 15.17.

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## Intermediate A-11

2-(5-Chloropyrazin-2-ylcarbonylamino)-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.



5  $^1\text{H-NMR}$  (DMSO)  $\delta$  9.16 (d,  $J = 1.5$  Hz), 9.00 (d,  $J = 1.1$  Hz), 8.74 (d,  $J = 8.8$  Hz), 8.50 (dd,  $J = 6.8$  Hz and 2.4 Hz), 8.21 (dd,  $J = 8.8$  Hz and 1.8 Hz), 8.13 (d,  $J = 8.8$  Hz), 8.02 (dd,  $J = 8.8$  Hz and 2.6 Hz), 3.90 (s).

FD-MS,  $m/e$  445.62 (M-1).

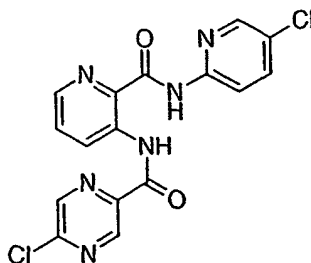
10 Analysis for  $\text{C}_{19}\text{H}_{13}\text{Cl}_2\text{N}_5\text{O}_4$  :

Calcd: C, 51.14; H, 2.94; N, 15.69;

Found: C, 50.84; H, 2.80; N, 15.40.

## Intermediate A-12

15 3-(5-Chloropyrazin-2-ylcarbonylamino)-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.



$^1\text{H-NMR}$  (DMSO)  $\delta$  9.28 (dd,  $J = 8.4$  Hz and 1.0 Hz), 9.19 (d,  $J = 1.1$  Hz), 9.07 (d,  $J = 1.1$  Hz), 8.48 - 8.54 (m), 8.26 (d,  $J = 8.8$  Hz), 8.10 (dd,  $J = 8.8$  Hz and 2.6 Hz), 7.81 - 7.86 (m).

ESI-MS,  $m/e$  389.10 (M+1).



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**Preparation of Intermediates B-1 - B-8**

The following intermediates were prepared by acylation of the requisite amine using 6-chloropyridazine-3-carbonyl chloride and a procedure similar to that described for the preparation of Intermediate A-1, or as otherwise described.

The 6-chloropyridazine-3-carbonyl chloride is conveniently prepared by conventional procedures as follows (Reference: J. Chem. Soc. 1948 2195-2198).

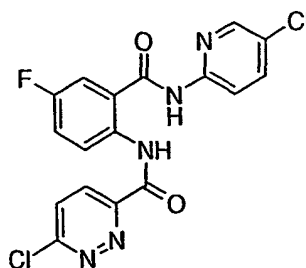
To a stirred solution of 3-chloro-6-methylpyridazine (11 g, 86 mmol) in H<sub>2</sub>SO<sub>4</sub> (100 mL) at 45 °C was added portion-wise K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> (30.3 g). The reaction was stirred at 45 °C for 4 h. The mixture was poured over ice and the resulting aqueous solution extracted with ethyl ether until no further product was obtained (about 4 L). The extracts were dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and the solvent removed. The resulting residue was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (20 mL) and triturated with hexanes. This afforded 5.1 g (32.2 mmol, 37% yield) of 6-chloropyridazine-3-carboxylic acid as a white solid.

To a solution of the acid (951 mg, 6.0 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (100 mL) at 0 °C was added pyridine (0.64 mL, 7.9 mmol) and DMF (2 drops) followed by oxalyl chloride (3.3 mL of a 2 M solution in CH<sub>2</sub>Cl<sub>2</sub>, 6.6 mmol). This was stirred at 0 °C for 30 min, then at room temperature for 1 h. This material was used without purification.

**Intermediate B-1**

**2-(6-Chloropyridazin-3-ylcarbonylamino)-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.**

-65-

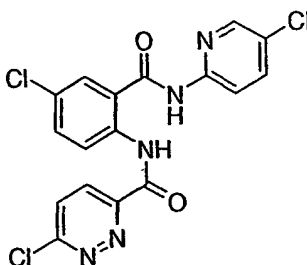


$^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  8.83 - 8.87 (m), 8.64 (s, br), 8.44 (d,  $J$  = 9.1 Hz), 8.34 (d,  $J$  = 8.8 Hz), 8.27 (s, br), 7.72 - 7.79 (m), 7.48 (dd,  $J$  = 8.7 Hz and 2.7 Hz), 7.32 - 7.38 (m).

5 ESI-MS,  $m/e$  406.35 ( $M+1$ ).

#### Intermediate B-2

**5-Chloro-2-(6-chloropyridazin-3-ylcarbonylamino)-N-(5-chloropyridin-2-yl)benzamide.**



10

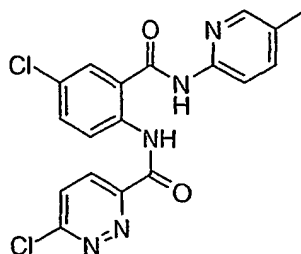
$^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  8.84 (d,  $J$  = 8.8 Hz), 8.62 (s, br), 8.43 (d,  $J$  = 8.8 Hz), 8.34 (d,  $J$  = 8.8 Hz), 8.28 (s, br), 7.78 (d,  $J$  = 2.2 Hz), 7.72 - 7.75 (m), 7.57 - 7.61 (2d,  $J_1$  = 2.2 Hz,  $J_2$  = 2.6 Hz).

15 ESI-MS,  $m/e$  421.94 ( $M+1$ ).

#### Intermediate B-3

**5-Chloro-2-(6-chloropyridazin-3-ylcarbonylamino)-N-(5-methylpyridin-2-yl)benzamide.**

-66-



$^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  8.61 (d,  $J$  = 9.1 Hz), 8.36 (d,  $J$  = 8.8 Hz), 8.24 (s, br), 8.17 (d,  $J$  = 8.8 Hz), 8.00 - 8.05 (m), 7.71 (dd,  $J$  = 9.0 Hz and 2.4 Hz), 2.30 (s).

5 ESI-MS,  $m/e$  402.17 ( $M+1$ ).

Analysis for  $\text{C}_{18}\text{H}_{13}\text{Cl}_2\text{N}_5\text{O}_2$

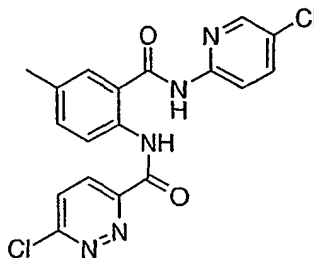
Calcd: C, 53.75; H, 3.26; N, 17.41;

Found: C, 53.66; H, 3.30; N, 17.18.

10

#### Intermediate B-4

2-(6-Chloropyridazin-3-ylcarbonylamino)-5-methyl-N-(5-chloropyridin-2-yl)benzamide.



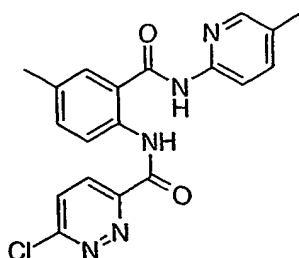
15  $^1\text{H-NMR}$  (DMSO)  $\delta$  8.46 - 8.49 (m), 8.35 (d,  $J$  = 8.8 Hz), 8.15 - 8.21 (m), 8.00 (d,  $J$  = 8.8 Hz and 2.6 Hz), 7.84 (d,  $J$  = 1.5 Hz), 7.47 (d,  $J$  = 8.4 Hz), 2.37 (s).

ESI-MS,  $m/e$  402.13 ( $M+1$ ).

#### Intermediate B-5

20 2-(6-Chloropyridazin-3-ylcarbonylamino)-5-methyl-N-(5-methylpyridin-2-yl)benzamide.

-67-



$^1\text{H-NMR}$  (DMSO)  $\delta$  8.50 (d,  $J = 8.4$  Hz), 8.35 (d,  $J = 8.8$  Hz),  
 8.23 (s, br), 8.16 (d,  $J = 8.8$  Hz), 8.04 (d,  $J = 8.4$  Hz),  
 7.85 (s), 7.70 (dd,  $J = 8.4$  Hz and 1.8 Hz), 7.45 (d,  $J = 8.4$   
 5 Hz), 2.37 (s), 2.29 (s).

ESI-MS,  $m/e$  382.24 ( $M+1$ ).

Analysis for  $\text{C}_{19}\text{H}_{16}\text{ClN}_5\text{O}_2$ :

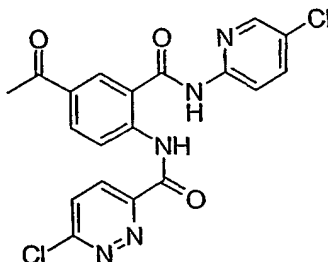
Calcd: C, 59.77; H, 4.22; N, 18.34;

Found: C, 59.72; H, 4.26; N, 18.13.

10

#### Intermediate B-6

**5-Acetyl-2-(3-Chloropyridazin-6-ylcarbonylamino)-  
 N-(5-chloropyridin-2-yl)benzamide.**



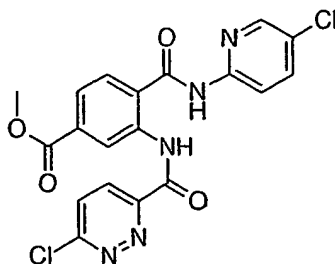
15  $^1\text{H-NMR}$

ESI-MS,  $m/e$  430.09 ( $M+1$ ).

#### Intermediate B-7

**2-(6-Chloropyridazin-3-ylcarbonylamino)-4-methoxycarbonyl-  
 20 N-(5-chloropyridin-2-yl)benzamide.**

-68-

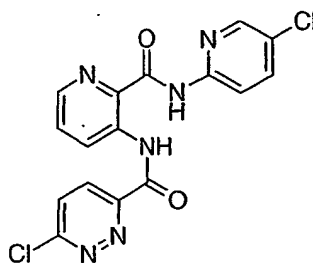


$^1\text{H-NMR}$  (DMSO)  $\delta$  9.16 (d,  $J = 1.5$  Hz), 8.48 (d,  $J = 2.6$  Hz), 8.38 (d,  $J = 8.8$  Hz), 8.19 (d,  $J = 8.8$  Hz), 8.00 - 8.10 (m), 7.84 (dd,  $J = 8.4$  Hz and 1.5 Hz), 3.93 (s).

5 ESI-MS,  $m/e$  446.08 ( $M+1$ ).

#### Intermediate B-8

3-(6-Chloropyridazin-3-ylcarbonylamino)-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.



10

$^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  9.36 (dd,  $J = 8.8$  Hz and 1.5 Hz), 8.53 (d,  $J = 8.8$  Hz), 8.32 - 8.41 (m), 7.72 - 7.77 (m), 7.57 - 7.61 (m).

ESI-MS,  $m/e$  388.61 ( $M+1$ ).

15

#### Preparation of Intermediates C-1 - C-3

The following intermediates were prepared by acylation of the requisite amine using 5-fluoropyrimidine-2-carbonyl chloride and a procedure similar to that described for the preparation of Intermediate A-1, or as otherwise described.

20

The 5-fluoropyrimidine-2-carbonyl chloride is conveniently prepared by conventional procedures as follows (Reference: Organic Preparations and Procedures Int., Vol. 27, No. 5, 1995, 600-602).

-69-

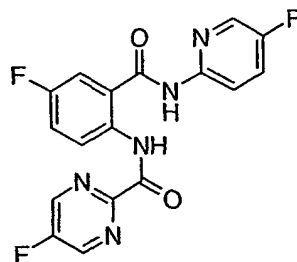
In a 2 L three neck flask equipped with a reflux condenser and an overhead stirrer was placed THF (500 mL), 2,4-dichloro-5-fluoropyrimidine (20 g, 120 mmol) and zinc (23.5 g, 360 mmol). This mixture was stirred vigorously and heated to reflux. To this was added over a 1 h period acetic acid. The reaction was stirred at reflux and monitored by GC/MS until complete. The reaction mixture was allowed to cool to room temperature, then poured into a solution of ethylenediaminetetraacetic acid tetrasodium salt in H<sub>2</sub>O. This was stirred at room temperature overnight. Diatomaceous earth was added, and the mixture filtered with ether washing. The ether solution was washed with brine, dried (Na<sub>2</sub>SO<sub>4</sub>), filtered, and the solvent removed, affording 5.1 g (38.5 mmol, 32% yield) of 2-chloro-5-fluoropyrimidine.

Using procedures similar to those described below for the preparation of 5-fluoropyridine-2-carbonyl chloride from 2-bromo-5-fluoropyridine, 2-chloro-5-fluoropyrimidine was converted into 5-fluoropyrimidine-2-carbonyl chloride.

20

**Intermediate C-1**

**5-Fluoro-2-(5-fluoropyrimidin-2-ylcarbonylamino)-N-(5-fluoropyridin-2-yl)benzamide.**



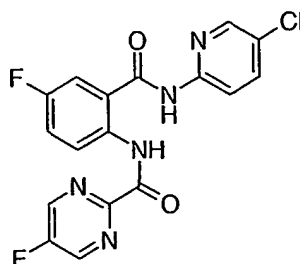
<sup>1</sup>H-NMR

ESI-MS, m/e 372.07 (M-1).

**Intermediate C-2**

**5-Fluoro-2-(5-fluoropyrimidin-2-ylcarbonylamino)-N-(5-chloropyridin-2-yl)benzamide.**

-70-

<sup>1</sup>H-NMR

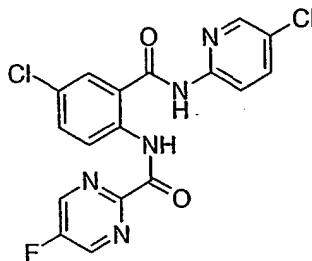
ESI-MS, m/e 388 (M-1).

Analysis for C<sub>17</sub>H<sub>10</sub>ClF<sub>2</sub>N<sub>5</sub>O<sub>2</sub>:

5            Calcd:     C, 52.39; H, 2.59; N, 17.97;  
              Found:     C, 52.44; H, 2.44; N, 17.77.

**Intermediate C-3**

2-(5-Fluoropyrimidin-2-ylcarbonylamino)-5-chloro-  
 10 N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

ESI-MS, m/e 403.9 (M-1).

Analysis for C<sub>19</sub>H<sub>12</sub>Cl<sub>2</sub>FN<sub>3</sub>O<sub>2</sub>:

15            Calcd:     C, 50.27; H, 2.48; N, 17.24;  
              Found:     C, 50.32; H, 2.22; N, 16.79.

**Preparation of Intermediates D-1 - D-6**

The following intermediates were prepared by acylation  
 20 of the requisite amine using 5-fluoropyridine-2-carbonyl  
 chloride and a procedure similar to that described for the  
 preparation of Intermediate A-1, or as otherwise described.

-71-

The 5-fluoropyridine-2-carbonyl chloride conveniently is prepared by conventional procedures as follows (Reference: Org. Syn. Collective Vol. 3, 136).

To HBr (222 mL, 48%, 1.96 M) at 0 °C was added portion-  
5 wise over 10 min 2-amino-5-fluoropyridine (50 g, 446 mmol)  
followed by drop-wise addition of Br<sub>2</sub> (67 mL, 1.32 mol) over  
20 min. A solution of NaNO<sub>2</sub> (77.5 g, 1.12 mol) in H<sub>2</sub>O  
(150 mL) was added drop-wise over 1 h, maintaining the  
temperature at 0 °C. This was stirred at 0 °C for 30 min,  
10 and a solution of NaOH (168 g, 4.2 mol) in H<sub>2</sub>O (168 mL) was  
added drop-wise maintaining the temperature below 10 °C.  
The reaction was then allowed to warm to room temperature  
and stirred for 20 min. The mixture was extracted with  
ether (6X500 mL). The extracts were dried (Na<sub>2</sub>SO<sub>4</sub>),  
15 filtered and the solvent removed. Flash chromatography with  
3-10% ethyl acetate in hexanes afforded 72.5 g, 412 mmol,  
(92% yield) of 2-bromo-5-fluoropyridine as a deep red oil.

A mixture of 2-bromo-5-fluoropyridine (72.5 g, 412  
mmol), palladium(II) acetate (2.5 g, 11.2 mmol),  
20 1,1'-bis(diphenylphosphino)ferrocene (11.9 g, 21.5 mmol),  
triethylamine (100 mL), CH<sub>3</sub>OH (350 mL), and DMF (350 mL)  
were shaken in a pressure apparatus at 80 °C under 4.1 bar  
(60 psig) carbon monoxide overnight. The crude mixture was  
diluted with ether (3 L) and filtered through diatomaceous  
25 earth. The filtrate was washed with brine (3X500 mL), dried  
(Na<sub>2</sub>SO<sub>4</sub>), filtered and the solvent removed. Flash  
chromatography, using 10-25% ethyl acetate in hexanes,  
afforded 26.2 g (169 mmol, 41% yield) of methyl  
5-fluoropyridine-2-carboxylate.

30 To a solution of the ester (5.7 g, 36.8 mmol) in CH<sub>3</sub>OH  
(100 mL) at room temperature was added a 1 M solution of  
lithium hydroxide in H<sub>2</sub>O (40.4 mL). This was stirred at  
room temperature overnight. The mixture was diluted with  
saturated NaHCO<sub>3</sub> (200 mL) and washed with ether. The



-72-

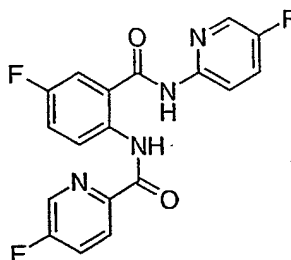
aqueous solution was made acidic with 6 N HCl and extracted with ethyl acetate (5X200 mL). The extracts were washed with brine, dried (MgSO<sub>4</sub>), filtered and the solvent removed affording 4.73 g (33.5 mmol, 91% yield) of 5-fluoropyridine-2-carboxylic acid.

The 5-fluoropyridine-2-carboxylic acid was converted into 5-fluoropyridine-2-carbonyl chloride using a procedure similar to that described above for the preparation of 6-chloropyridazine-3-carbonyl chloride.

10

**Intermediate D-1**

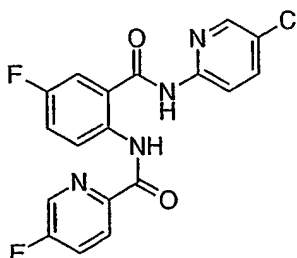
**5-Fluoro-2-(5-fluoropyridin-2-ylcarbonylamino)-N-(5-fluoropyridin-2-yl)benzamide.**

15 <sup>1</sup>H-NMR

ESI-MS, m/e 373.09 (M+1).

**Intermediate D-2**

**5-Fluoro-2-(5-fluoropyridin-2-ylcarbonylamino)-N-(5-chloropyridin-2-yl)benzamide.**



<sup>1</sup>H-NMR (DMSO, 250 MHz)  $\delta$  8.76 (d, J = 2.7 Hz), 8.56 - 8.62 (m), 8.49 (d, J = 2.7 Hz), 8.24 - 8.29 (m), 8.16 (d, J = 8.8

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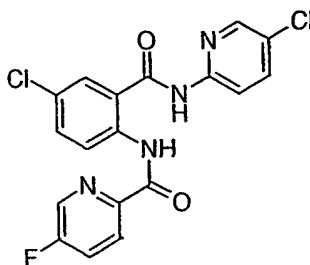
Hz), 7.95 - 8.05 (m), 7.80 (dd,  $J = 9.2$  Hz and  $3.1$  Hz),  
7.49 - 7.57 (m).

ESI-MS,  $m/e$  389.15 (M+1).

5

**Intermediate D-3**

**5-Chloro-2-(5-fluoropyridin-2-ylcarbonylamino)-N-(5-chloro-pyridin-2-yl)benzamide.**

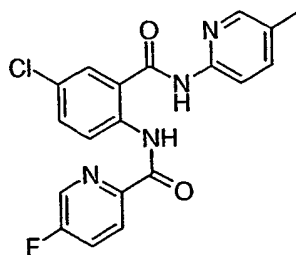


10  $^1\text{H-NMR}$  (DMSO, 250 MHz)  $\delta$  7.77 (d,  $J = 3.1$  Hz), 8.62 (d,  $J = 9.2$  Hz), 8.49 (d,  $J = 2.7$  Hz), 8.24 - 8.29 (m), 8.15 (d,  $J = 8.4$  Hz), 7.95 - 8.05 (m), 7.71 (dd,  $J = 8.8$  Hz and  $2.4$  Hz).  
FD-MS,  $m/e$  405.5 (M+1).

15

**Intermediate D-4**

**5-Chloro-2-(5-fluoropyridin-2-ylcarbonylamino)-N-(5-methyl-pyridin-2-yl)benzamide.**

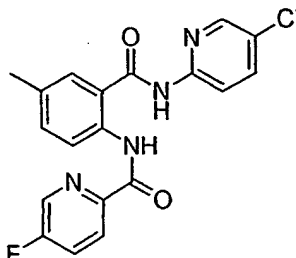


20  $^1\text{H-NMR}$  (DMSO, 250 MHz)  $\delta$  8.82 (d,  $J = 2.7$  Hz), 8.71 (d,  $J = 8.8$  Hz), 8.29 - 8.34 (m), 8.01 - 8.08 (m), 7.73 - 7.80 (m),  
2.36 (s).  
ESI-MS,  $m/e$  385.08 (M+1).

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## Intermediate D-5

2-(5-Fluoropyridin-2-ylcarbonylamino)-5-methyl-N-(5-chloro-pyridin-2-yl)benzamide.



5  $^1\text{H-NMR}$  (DMSO, 250 MHz)  $\delta$  8.76 (d,  $J = 3.0$ ), 8.53 (s), 8.47 - 8.49 (m), 8.23 - 8.28 (m), 8.16 (d,  $J = 8.8$  Hz), 7.94 - 8.08 (m), 7.79 (d,  $J = 1.5$  Hz), 7.46 (dd), 2.37 (s).

ESI-MS,  $m/e$  385.08 ( $M+1$ ).

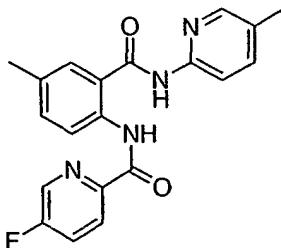
Analysis for  $\text{C}_{19}\text{H}_{14}\text{ClFN}_4\text{O}_2$ :

10 Calcd: C, 59.31; H, 3.67; N, 14.56;

Found: C, 59.17; H, 3.42; N, 14.48.

## Intermediate D-6

15 2-(5-Fluoropyridin-2-ylcarbonylamino)-5-methyl-N-(5-methyl-pyridin-2-yl)benzamide.



$^1\text{H-NMR}$

ESI-MS,  $m/e$  365.2 ( $M+1$ ).

20

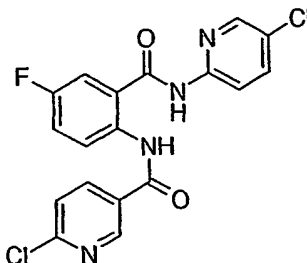
## Preparation of Intermediates E-1 - E-5

The following intermediates were prepared by acylation of the requisite amine using 6-chloropyridine-3-carbonyl chloride and a procedure similar to that described for the preparation of Intermediate A-1, or as otherwise described.

-75-

## Intermediate E-1

2-(6-Chloropyridin-3-ylcarbonylamino)-5-fluoro-N-(5-chloro-pyridin-2-yl)benzamide.



5

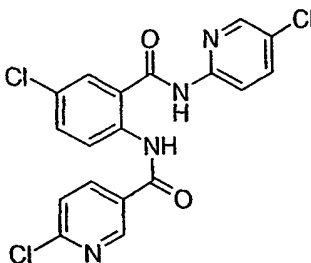
$^1\text{H-NMR}$  (DMSO, 250 MHz)  $\delta$  8.89 (d,  $J = 2.4$  Hz), 8.43 (d,  $J = 2.7$  Hz), 8.25 - 8.30 (m), 8.14 (d,  $J = 8.8$  Hz), 7.92 - 7.98 (m), 7.64 - 7.74 (m), 7.45 - 7.53 (m).

ESI-MS,  $m/e$  405.24 ( $M+1$ ).

10

## Intermediate E-2

5-Chloro-2-(6-chloropyridin-3-ylcarbonylamino)-N-(5-chloro-pyridin-2-yl)benzamide.



15  $^1\text{H-NMR}$  (DMSO, 250 MHz)  $\delta$  8.89 (d,  $J = 2.1$ ), 8.44 (d,  $J = 2.1$  Hz), 8.28 (dd,  $J = 8.2$  Hz and 2.4 Hz), 8.14 (d,  $J = 9.1$  Hz), 7.94 - 8.03 (m), 7.88 (d,  $J = 2.4$ ), 7.76 - 7.75 (m).

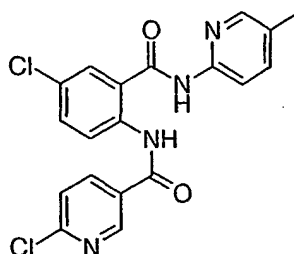
ESI-MS,  $m/e$  420.93 ( $M+1$ ).

20

## Intermediate E-3

5-Chloro-2-(6-chloropyridin-3-ylcarbonylamino)-N-(5-methyl-pyridin-2-yl)benzamide.

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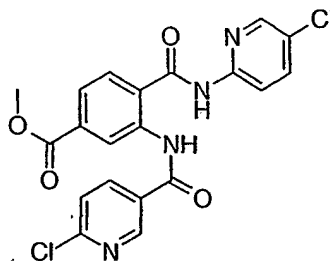
$^1\text{H-NMR}$  (DMSO)  $\delta$  8.88 (d,  $J = 2.6$  Hz), 8.12 - 8.29 (m), 7.92 - 7.99 (m), 7.64 - 7.73 (m), 2.27 (s).

ESI-MS,  $m/e$  401.07 ( $M+1$ ).

5

#### Intermediate E-4

2-(6-Chloropyridin-3-ylcarbonylamino)-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

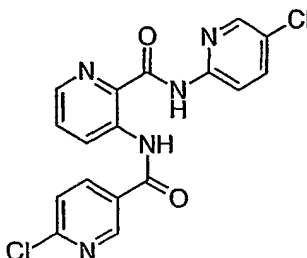


10  $^1\text{H-NMR}$

ESI-MS,  $m/e$  443.17 ( $M-1$ ).

#### Intermediate E-5

15 3-[6-Chloropyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.



-77-

<sup>1</sup>H-NMR (DMSO) δ 9.08 (d, J = 8.4 Hz), 9.00 (s, br), 8.49 - 8.54 (m), 8.37 (d, J = 8.4 Hz), 8.28 (d, J = 8.4 Hz), 8.06 (d, J = 8.8 Hz), 7.83 (d, J = 8.1 Hz).

ESI-MS, m/e 386.13 (M-1).

5

### Preparation of Examples P1 - P31

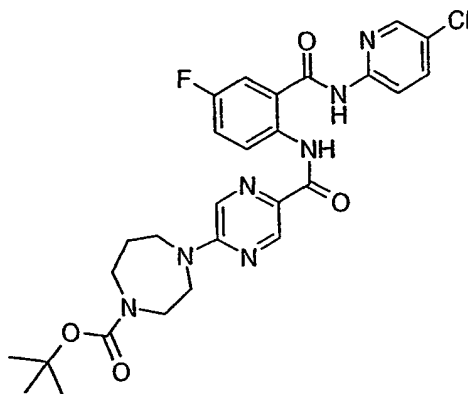
The following protected examples were prepared using 1-t-butoxycarbonylhexahydro-1,4-diazepine and the requisite intermediate and a procedure similar to that described for the preparation of Example P1, or as otherwise described.

10

#### Example P1

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)-benzamide.

15



To a solution (or suspension) of 2-(5-chloropyrazin-2-ylcarbonylamino)-5-fluoro-N-(5-chloropyridin-2-yl)benzamide (Intermediate A-1, 10 g, 24.62 mmol) in DMSO (30 mL) was added 1-Boc-hexahydro-1,4-diazepine (9.86 g, 49.23 mmol) and pyridine (2.4 mL, 30 mmol). The reaction mixture was stirred for one hour at room temperature before it was heated in a sealed tube at 75-80 °C for 18 h. The mixture was cooled to room temperature, diluted with ethyl acetate (800 mL), washed with saturated aqueous citric acid solution (3 x 200 mL), water (200 mL), saturated sodium bicarbonate

20

25

-78-

solution (2 x 200 mL), and dried over magnesium sulfate. Activated charcoal (3 g) was added to decolorize the product. Evaporation of the solvent under vacuum provided 13.9 g of crude product. Ether (150 mL) was added to this solid, the mixture was sonicated 20 min, and the solids were filtered and dried under vacuum to afford the title compound as a solid which was analytically pure. Yield = 12.6 g

<sup>1</sup>H-NMR

10 ESI-MS, m/e 570.36 (M+1).

Analysis for C<sub>27</sub>H<sub>29</sub>ClFN<sub>7</sub>O<sub>4</sub>:

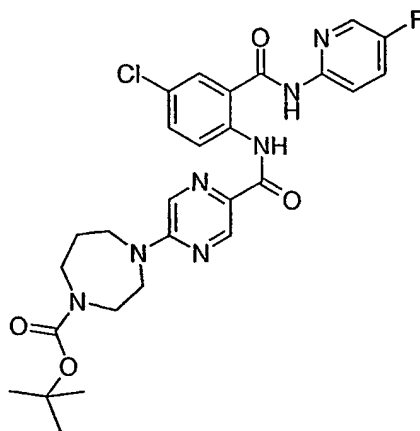
Calcd: C, 56.89; H, 5.13; N, 17.20;

Found: C, 56.76; H, 5.14; N, 16.88.

15

## Example P2

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-chloro-N-(5-fluoropyridin-2-yl)-benzamide.

20 <sup>1</sup>H-NMR

ESI-MS, m/e 570.35 (M+1).

Analysis for C<sub>27</sub>H<sub>29</sub>ClFN<sub>7</sub>O<sub>4</sub>:

Calcd: C, 56.89; H, 5.13; N, 17.20;

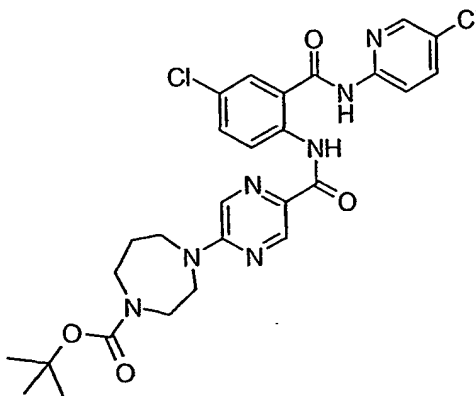
Found: C, 56.57; H, 5.07; N, 16.97.

25

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## Example P3

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-chloro-N-(5-chloropyridin-2-yl)-benzamide.



5

<sup>1</sup>H-NMR

ESI-MS, m/e 586.24 (M+1).

Analysis for C<sub>27</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>7</sub>O<sub>4</sub>:

Calcd: C, 55.30; H, 4.98; N, 16.72;

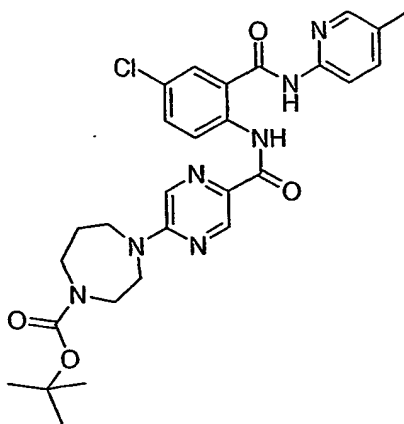
10

Found: C, 55.13; H, 5.09; N, 16.86.

## Example P4

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-chloro-N-(5-methylpyridin-2-yl)-benzamide.

15





-80-

<sup>1</sup>H-NMR

ESI-MS, m/e 566.54 (M+1).

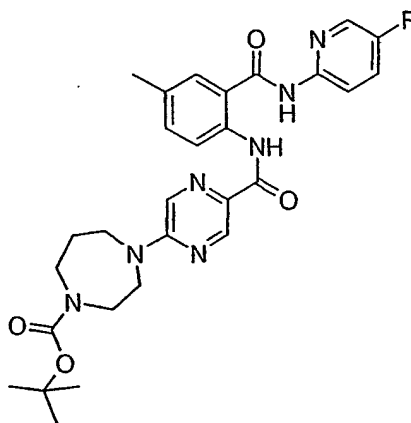
Analysis for C<sub>28</sub>H<sub>32</sub>ClN<sub>7</sub>O<sub>4</sub>:

Calcd: C, 59.41; H, 5.70; N, 17.32;

5 Found: C, 59.30; H, 5.49; N, 17.22.

## Example P5

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-  
2-ylcarbonylamino]-5-methyl-N-(5-fluoropyridin-2-yl)-  
10 benzamide.

<sup>1</sup>H-NMR

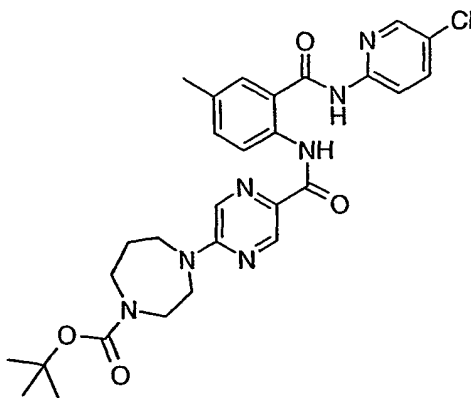
ESI-MS, m/e 550.36 (M+1).

15

## Example P6

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-  
2-ylcarbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)-  
benzamide.

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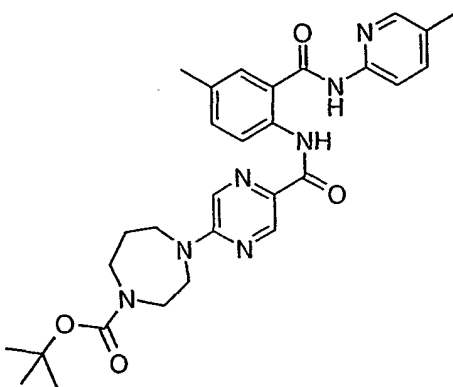
<sup>1</sup>H-NMR

ESI-MS, m/e 566.53 (M+1).

5

**Example P7**

2-[5-(4-*t*-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-methyl-N-(5-methylpyridin-2-yl)-benzamide.

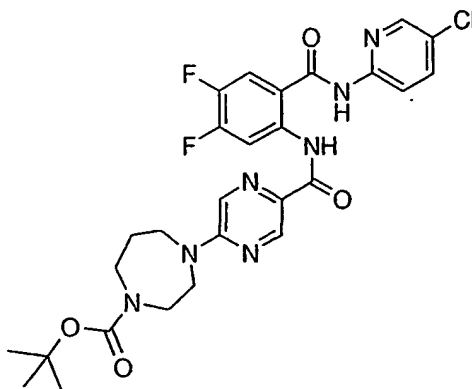
10 <sup>1</sup>H-NMR

ESI-MS, m/e 546.22 (M+1).

**Example P8**

2-[5-(4-*t*-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)-4,5-difluoro-N-(5-chloropyridin-2-yl)benzamide.

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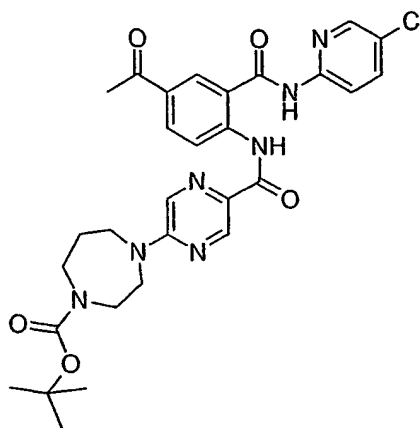
<sup>1</sup>H-NMR

ESI-MS, m/e 586.1 (M-1).

5

**Example P9**

5-Acetyl-2-[5-(4-t-butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.

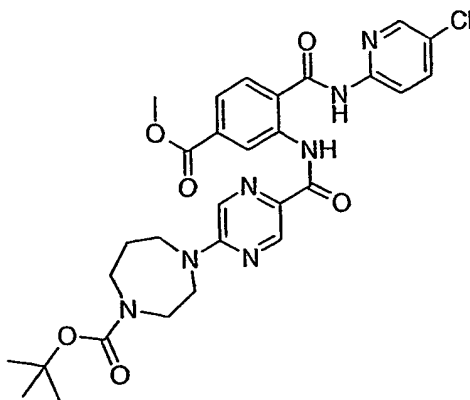
10 <sup>1</sup>H-NMR

ESI-MS, m/e 594.47 (M+1).

**Example P10**

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

-83-

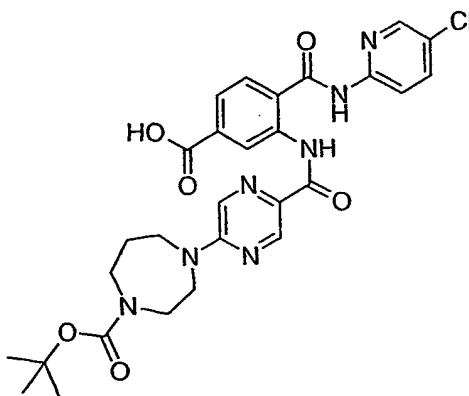
<sup>1</sup>H-NMR

ESI-MS, m/e 610.19 (M+1).

5

**Example P11**

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-4-carboxy-N-(5-chloropyridin-2-yl)-benzamide.



- 10 To a solution of 2-[5-(4-t-butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide (Example P10, 0.610 g, 1 mmol) in THF (6 mL) and water (2 mL) was added lithium hydroxide (0.240 g), and the solution was stirred overnight.
- 15 THF was evaporated off under vacuum, and the remaining aqueous layer was acidified to pH 2 with 0.1 N HCl before it was extracted with ethyl acetate (3 x 20 mL), dried over magnesium sulfate and the solvent evaporated. This crude

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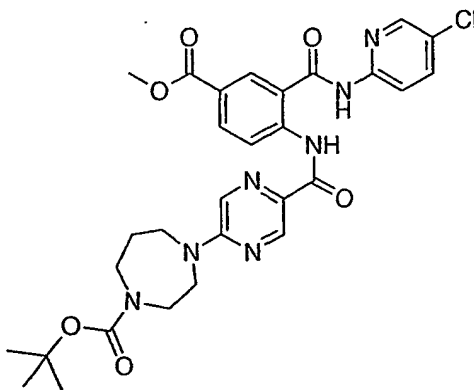
product was used as such for deprotection in the next step.  
Yield = 0.47 g.

<sup>1</sup>H-NMR

5 ESI-MS, m/e 596.37 (M+1).

Example P12

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.



<sup>1</sup>H-NMR

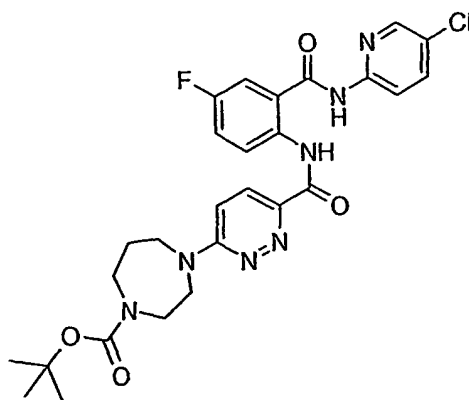
ESI-MS, m/e 610.19 (M+1).

15

Example P13

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)-benzamide.

-85-

<sup>1</sup>H-NMR

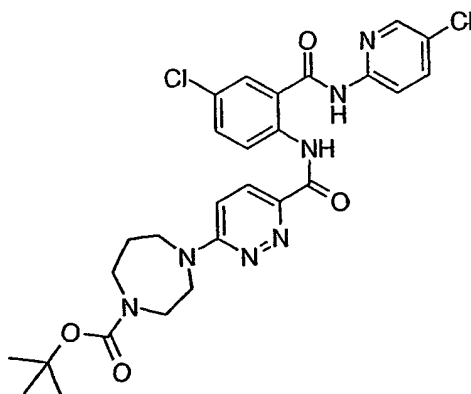
ESI-MS, m/e 570.41 (M+1).

Analysis for C<sub>27</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>7</sub>O<sub>4</sub>:

5            Calcd:      C, 56.89; H, 5.13; N, 17.20;  
              Found:      C, 56.62; H, 4.98; N, 17.00.

**Example P14**

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrid-  
 10    azin-3-ylcarbonylamino]-5-chloro-N-(5-chloropyridin-2-yl)-  
       benzamide.

<sup>1</sup>H-NMR

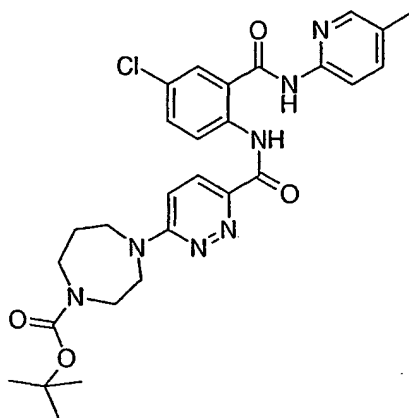
ESI-MS, m/e 586.23 (M+1).

15

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## Example P15

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-5-chloro-N-(5-methylpyridin-2-yl)-benzamide.



5

<sup>1</sup>H-NMR

ESI-MS, m/e 566.54 (M+1).

Analysis for C<sub>28</sub>H<sub>32</sub>ClN<sub>7</sub>O<sub>4</sub>:

Calcd: C, 59.41; H, 5.70; N, 17.32;

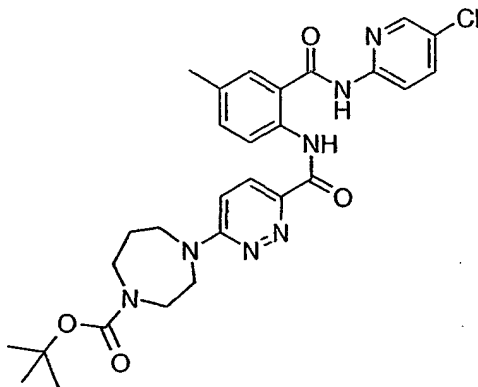
10

Found: C, 58.91; H, 5.62; N, 16.97.

## Example P16

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)-benzamide.

15



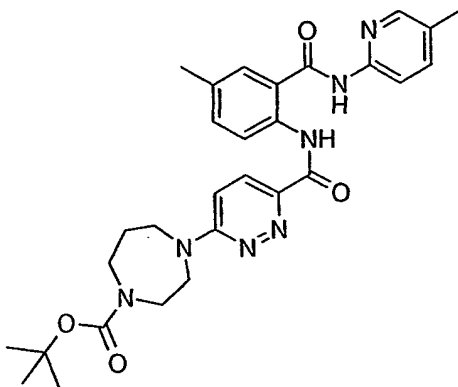
-87-

<sup>1</sup>H-NMR

ESI-MS, m/e 566.53 (M+1).

## Example P17

- 5 2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-5-methyl-N-(5-methylpyridin-2-yl)-benzamide.

<sup>1</sup>H-NMR

- 10 ESI-MS, m/e 546.20 (M+1).

Analysis for C<sub>29</sub>H<sub>35</sub>N<sub>7</sub>O<sub>4</sub>:

Calcd: C, 63.84; H, 6.47; N, 17.97;

Found: C, 63.35; H, 6.57; N, 17.70.

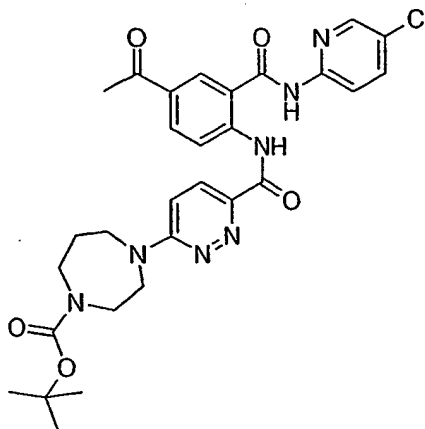
15

## Example P18

- 5-Acetyl-2-[6-(4-t-butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.



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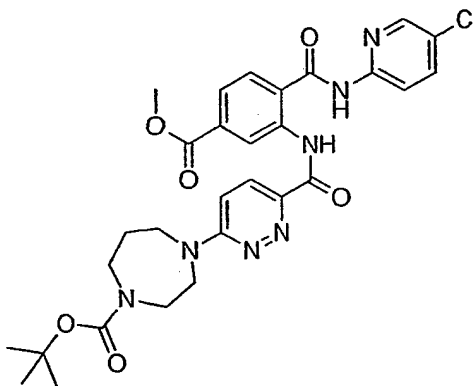
<sup>1</sup>H-NMR

ESI-MS, m/e 592.54 (M-1).

5

**Example P19**

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

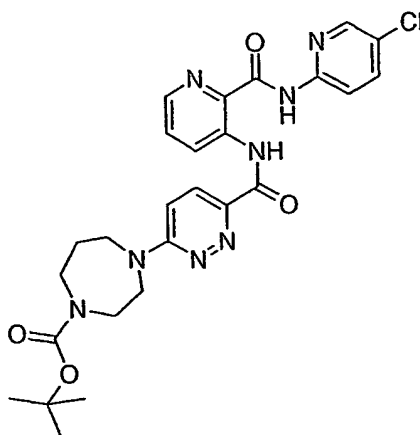
10 <sup>1</sup>H-NMR

ESI-MS, m/e 610.26 (M+1).

**Example P20**

3-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-6-oylcarbonylamino]-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.

-89-

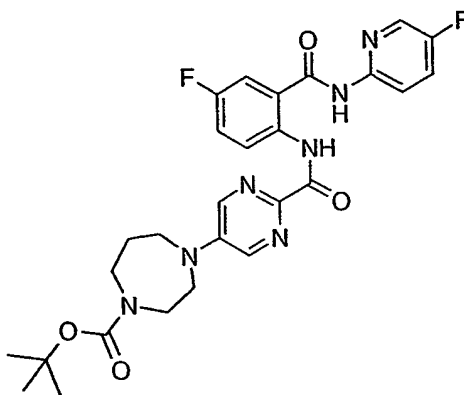
<sup>1</sup>H-NMR

ESI-MS, m/e 553.29 (M+1).

5

**Example P21**

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)-  
pyrimidin-2-ylcarbonylamino]-5-fluoro-N-(5-fluoropyridin-2-  
yl)benzamide.

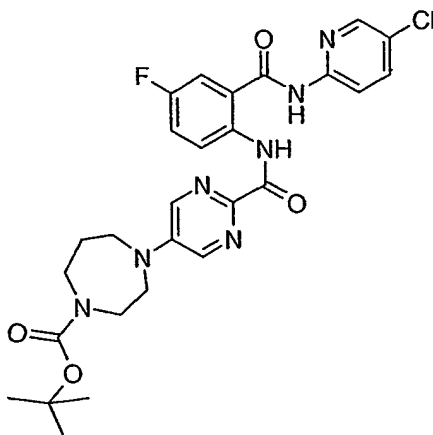
10 <sup>1</sup>H-NMR

ESI-MS, m/e 552.3 (M-1).

**Example P22**

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyrim-  
15 idin-2-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)-  
benzamide.

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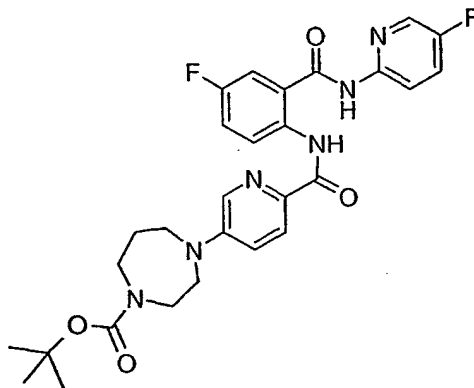
<sup>1</sup>H-NMR

ES+-MS, m/e 568.25 (M-1).

5

## Example P23

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-5-fluoro-N-(5-fluoropyridin-2-yl)-benzamide.

10 <sup>1</sup>H-NMR

ESI-MS, m/e 551.27 (M-1).

Analysis for C<sub>28</sub>H<sub>30</sub>F<sub>2</sub>N<sub>6</sub>O<sub>4</sub>:

Calcd: C, 60.86; H, 5.47; N, 15.20;

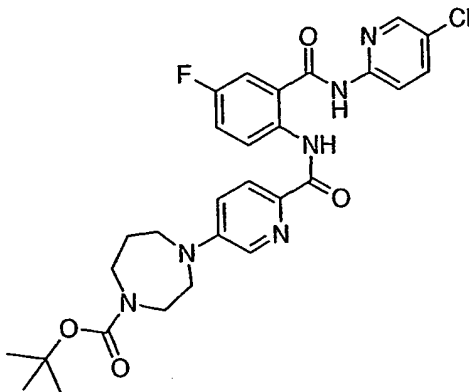
Found: C, 60.91; H, 5.46; N, 15.02.

15

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## Example P24

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)-benzamide.



5

 $^1\text{H-NMR}$ ESI-MS,  $m/e$  567.52 ( $M-1$ ).Analysis for  $\text{C}_{28}\text{H}_{30}\text{ClFN}_6\text{O}_4$ :

Calcd: C, 59.10; H, 5.31; N, 14.77;

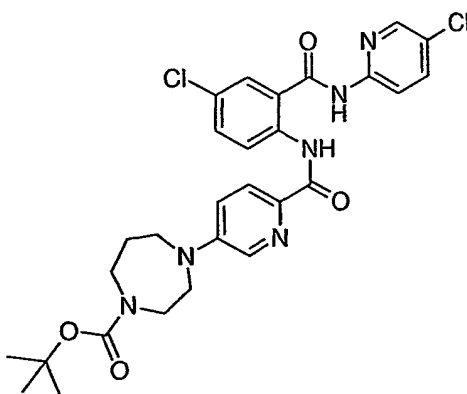
10

Found: C, 58.86; H, 5.21; N, 14.56.

## Example P25

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-5-chloro-N-(5-chloropyridin-2-yl)-benzamide.

15

 $^1\text{H-NMR}$ ESI-MS,  $m/e$  584.9 ( $M^+$ ).

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Analysis for  $C_{27}H_{29}Cl_2N_7O_4$ :

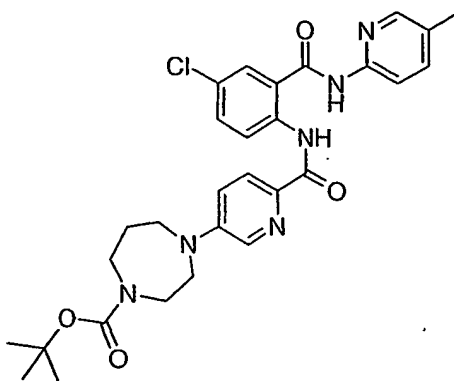
Calcd: C, 57.44; H, 5.17; N, 14.35;

Found: C, 57.16; H, 5.22; N, 14.25.

5

## Example P26

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-5-chloro-N-(5-methylpyridin-2-yl)-benzamide.

10  $^1H$ -NMR

ESI-MS, m/e 565.50 (M+1).

Analysis for  $C_{29}H_{33}ClN_6O_4$ :

Calcd: C, 61.64; H, 5.89; N, 14.87;

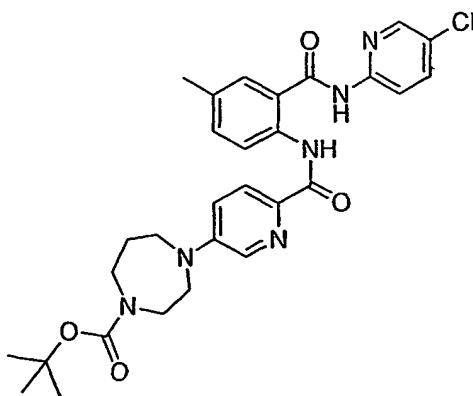
Found: C, 61.57; H, 5.91; N, 14.58.

15

## Example P27

2-[5-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)-benzamide.

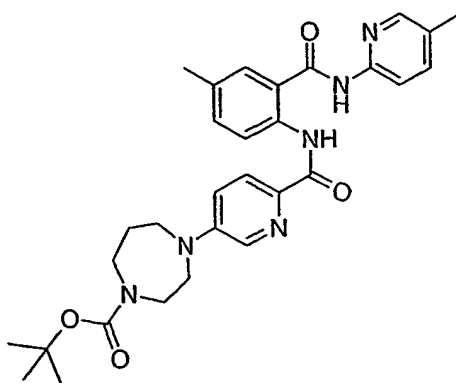
-93-

 $^1\text{H-NMR}$ ESI-MS,  $m/e$  563.45 ( $M-1$ ).

5

**Example P28**

2-[5-(4-*t*-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-5-methyl-*N*-(5-methylpyridin-2-yl)-benzamide.

10  $^1\text{H-NMR}$ ESI-MS,  $m/e$  545.33 ( $M+1$ ).Analysis for  $\text{C}_{30}\text{H}_{36}\text{N}_6\text{O}_4$ :

Calcd: C, 66.16; H, 6.66; N, 15.43;

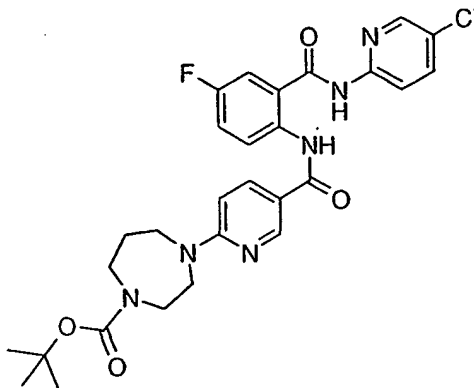
Found: C, 66.24; H, 6.40; N, 15.06.

15

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## Example P29

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)-benzamide.

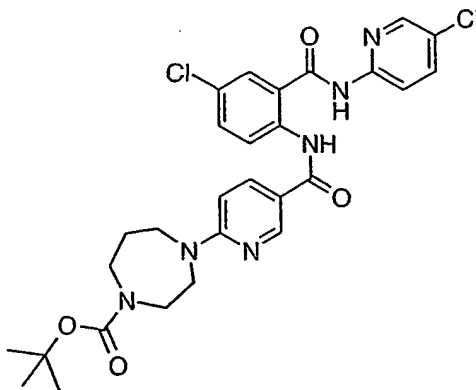


5

 $^1\text{H-NMR}$ ESI-MS,  $m/e$  569.38 ( $M+1$ ).

## Example P30

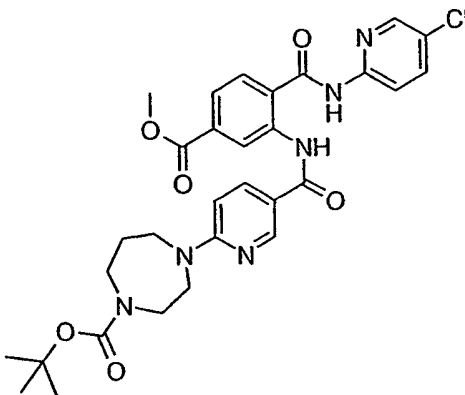
10 2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-5-chloro-N-(5-chloropyridin-2-yl)-benzamide.

 $^1\text{H-NMR}$ 15 ESI-MS,  $m/e$  585.13 ( $M+1$ ).

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**Example P31**

2-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.



5

<sup>1</sup>H-NMR

ESI-MS, m/e 609.17 (M+1).

Analysis for C<sub>30</sub>H<sub>33</sub>ClN<sub>6</sub>O<sub>6</sub>:

Calcd: C, 59.16; H, 5.46; N, 13.80;

10

Found: C, 58.80; H, 5.53; N, 13.49.

**Preparation of Examples 1 - 33**

The following examples were prepared using the requisite 1-t-butoxycarbonyl protected hexahydro-1,4-diazepine described above and a procedure similar to that described for the preparation of Example 1, or as otherwise described.

**Preparation of salts**

20 TFA salts were obtained by removal of the solvent after the deprotection of nitrogen in methylene chloride and TFA.

Monohydrochlorides were prepared by treating the free bases suspended in methylene chloride, methanol mixture  
25 (4:1) with one equivalent of HCl in ether and sonicating for five minutes and evaporating off the solvent.



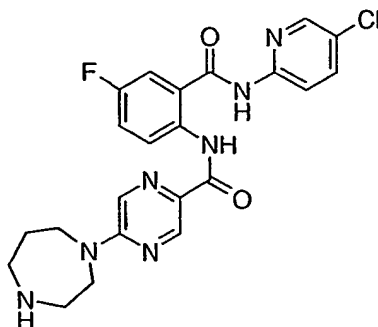
-96-

Similarly the polyhydrochlorides were prepared by treatment with excess HCl in ether.

5

**Example 1**

**5-Fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-yl-carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**



To a suspension of 2-[5-(4-t-butoxycarbonylhexahydro-  
10 1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide (Example P1, 11.4 g) in methylene chloride (30 mL) and anisole (10 mL) was added trifluoroacetic acid (30 mL) dropwise. The mixture was stirred overnight at room temperature before the solvent was  
15 evaporated. The residue was purified by using an SCX column. Yield 8.1 g.

<sup>1</sup>H-NMR

FD-MS, m/e 470.20 (M<sup>+</sup>).

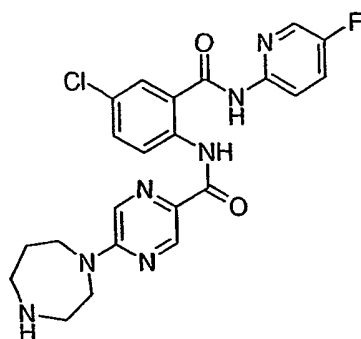
20

Also prepared were the hydrochloride and dihydrochloride salts.

**Example 2**

25 **5-Chloro-2-[5-(hexahydro-1,4-diazepin-1-yl)-pyrazin-2-yl-carbonylamino]-N-(5-fluoropyridin-2-yl)benzamide.**

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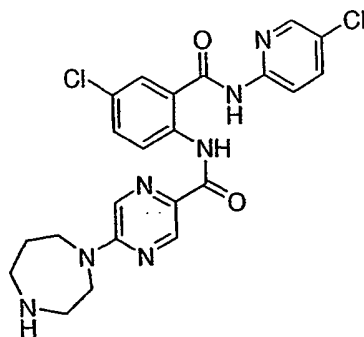
<sup>1</sup>H-NMR

ESI-MS, m/e 470.15 (M+1).

5

**Example 3**

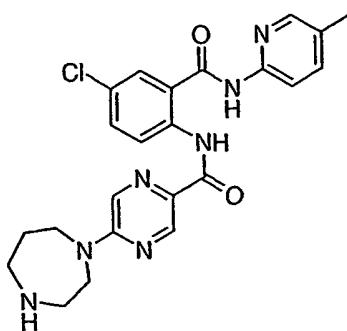
5-Chloro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

10 ESI-MS, m/e 484.36 (M-1).

**Example 4**

5-Chloro-2-[5-(hexahydro-1,4-diazepin-1-yl)-pyrazin-2-yl]-  
carbonylamino]-N-(5-methylpyridin-2-yl)benzamide.



15

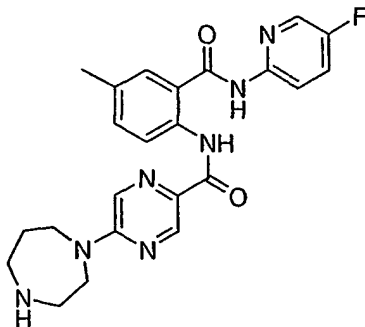
-98-

<sup>1</sup>H-NMR

ESI-MS, m/e 466.19 (M+1).

## Example 5

- 5 2-[5-(Hexahydro-1,4-diazepin-1-yl)-pyrazin-2-ylcarbonyl-  
amino]-5-methyl-N-(5-fluoropyridin-2-yl)benzamide.

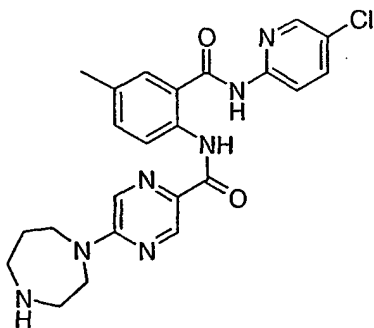
<sup>1</sup>H-NMR

ESI-MS, m/e 450.11 (M+1).

10

## Example 6

- 2-[5-(Hexahydro-1,4-diazepin-1-yl)pyrazin-2-oylcarbonyl-  
amino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.

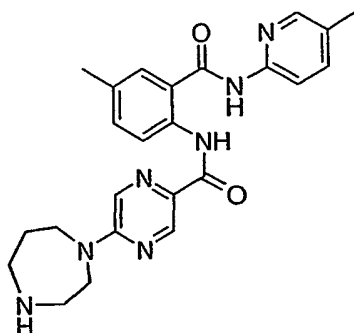
15 <sup>1</sup>H-NMR

ESI-MS, m/e 466.29 (M+1).

## Example 7

- 20 2-[5-(Hexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonyl-  
amino]-5-methyl-N-(5-methylpyridin-2-yl)benzamide.

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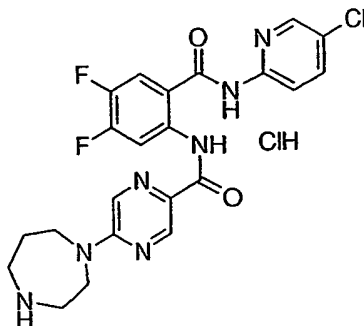
<sup>1</sup>H-NMR

ESI-MS, m/e 446.20 (M+1).

5

**Example 8**

**4,5-Difluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide  
Hydrochloride.**

10 <sup>1</sup>H-NMR

ESI-MS, m/e 486.45 (M-1).

Analysis for C<sub>22</sub>H<sub>20</sub>ClF<sub>2</sub>N<sub>7</sub>O<sub>2</sub>·HCl:

Calcd: C, 50.39; H, 4.04; N, 18.69;

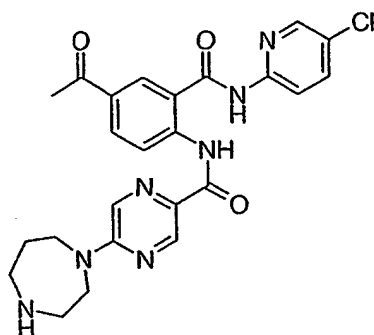
Found: C, 50.31; H, 3.83; N, 18.12.

15

**Example 9**

**5-Acetyl-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

-100-

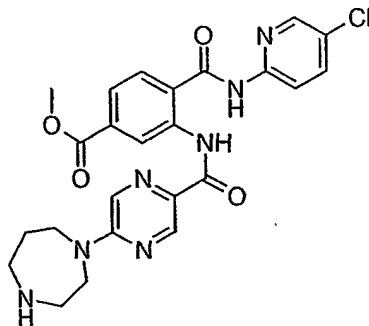
<sup>1</sup>H-NMR

ESI-MS, m/e 494.46 (M+1).

5

**Example 10**

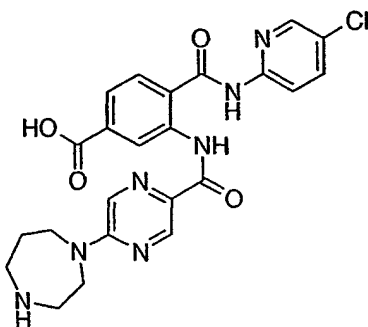
2-[5-(Hexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonyl-amino]-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

10 ESI-MS, m/e 510.26 (M+1).

**Example 11**

4-Carboxy-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.



15

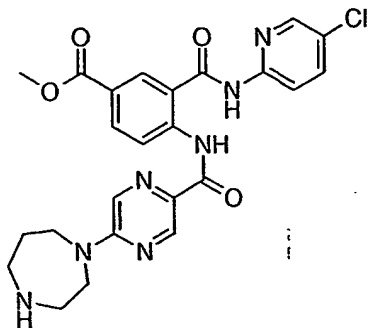
-101-

<sup>1</sup>H-NMR

ESI-MS, m/e 494.31 (M-1).

## Example 12

- 5    2-[5-(Hexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonyl-  
amino]-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

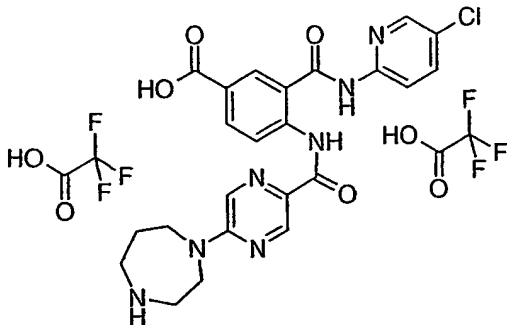
<sup>1</sup>H-NMR

ESI-MS, m/e 510.31 (M+1).

10

## Example 13

- 5-Carboxy-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-yl-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide  
Bis(trifluoroacetate).



15

The N-protected acid was prepared from the N-protected ester of Example P12 using a procedure similar to that of Example P11 before the N-protecting group was removed.

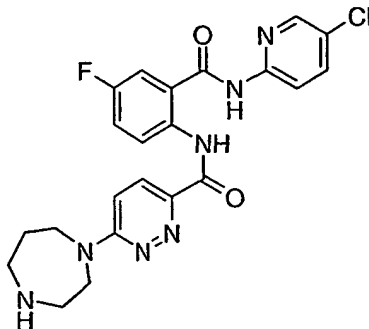
20    <sup>1</sup>H-NMR

ESI-MS, m/e 496.17 (M+1).

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## Example 14

5-Fluoro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-yl-carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.



5

<sup>1</sup>H-NMR

ESI-MS, m/e 470.16 (M+1).

Analysis for C<sub>22</sub>H<sub>21</sub>ClFN<sub>7</sub>O<sub>2</sub>:

Calcd: C, 56.23; H, 4.50; N, 20.87;

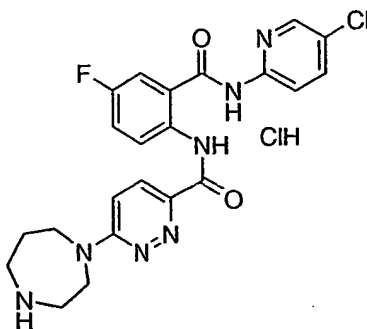
10

Found: C, 55.73; H, 4.23; N, 20.70.

## Example 14a

5-Fluoro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-yl-carbonylamino]-N-(5-chloropyridin-2-yl)benzamide

15 Hydrochloride.

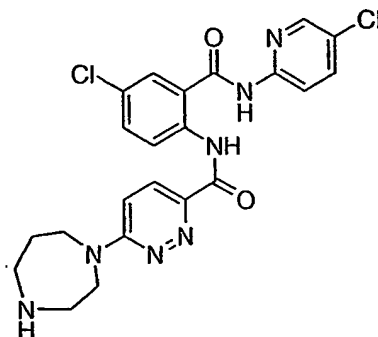
<sup>1</sup>H-NMR

ESI-MS, m/e 468.18 (M-1).

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## Example 15

5-Chloro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-yl-carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

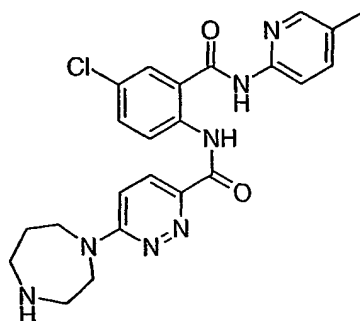


5  $^1\text{H-NMR}$

ESI-MS, m/e 486.44 (M+1).

## Example 16

5-Chloro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-yl-carbonylamino]-N-(5-methylpyridin-2-yl)benzamide.



$^1\text{H-NMR}$

ESI-MS, m/e 466.18 (M+1).

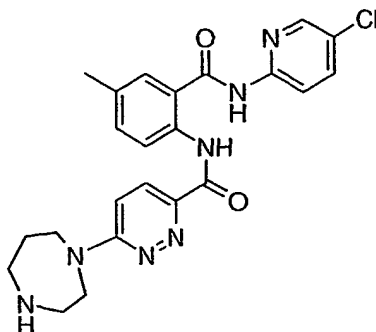
15

## Example 17

2-[6-(Hexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.



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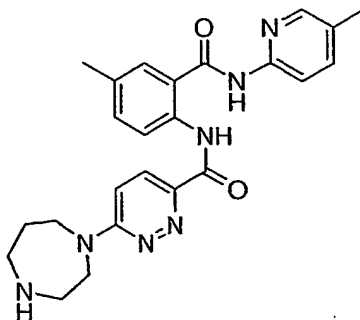
<sup>1</sup>H-NMR

ESI-MS, m/e 466.17 (M+1).

5

**Example 18**

2-[6-(Hexahydro-1,4-diazepin-1-yl)pyridazin-3-yl]carbonyl-  
amino]-5-methyl-N-(5-methylpyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

10 ESI-MS, m/e 446.17 (M+1).

Analysis for C<sub>24</sub>H<sub>27</sub>N<sub>7</sub>O<sub>2</sub>:

Calcd: C, 64.70; H, 6.11; N, 22.01;

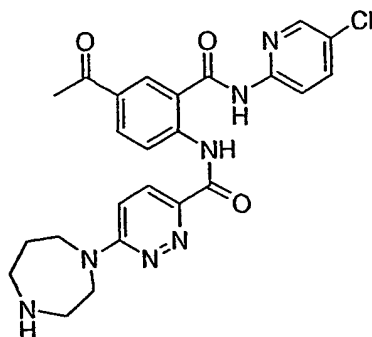
Found: C, 64.36; H, 6.12; N, 21.53.

15

**Example 19**

5-Acetyl-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

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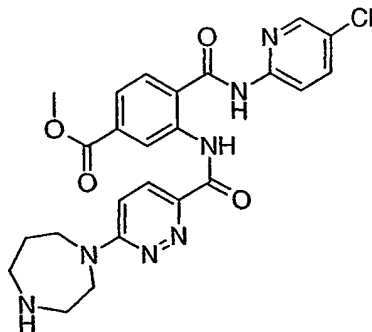
<sup>1</sup>H-NMR

ESI-MS, m/e 494.25 (M+1).

5

**Example 20**

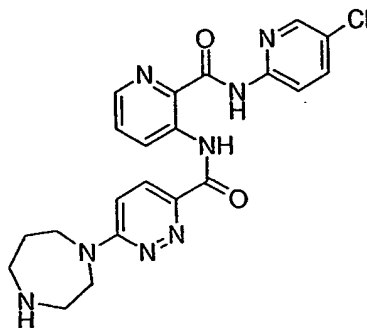
2-[6-(Hexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonyl-amino]-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

10 ESI-MS, m/e 510.30 (M+1).

**Example 21**

3-[6-(Hexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonyl-amino]-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.



15

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<sup>1</sup>H-NMR

ESI-MS, m/e 453.02 (M+1).

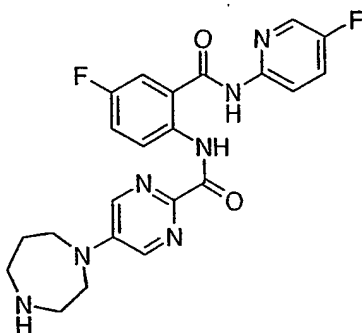
Analysis for C<sub>21</sub>H<sub>21</sub>ClN<sub>8</sub>O<sub>2</sub>:

Calcd: C, 55.69; H, 4.67; N, 24.74;

5 Found: C, 55.55; H, 4.59; N, 24.54.

## Example 22

5-Fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrimidin-2-yl]-  
carbonylamino]-N-(5-fluoropyridin-2-yl)benzamide.



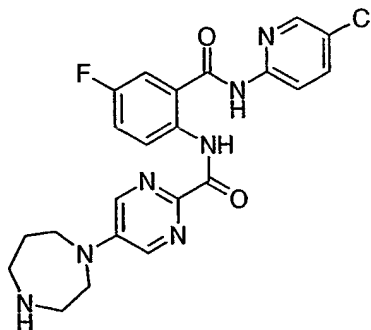
10

<sup>1</sup>H-NMR

ESI-MS, m/e 452.34 (M-1).

## Example 23

15 5-Fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrimidin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

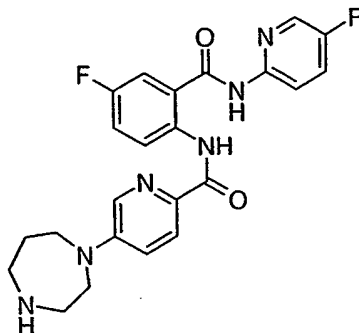
ESI-MS, m/e 468.18 (M-1).

20

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## Example 24

5-Fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyridin-2-yl]-  
carbonylamino]-N-(5-fluoropyridin-2-yl)benzamide.



5  $^1\text{H-NMR}$

ESI-MS, m/e 451.23 (M-1).

Analysis for  $\text{C}_{23}\text{H}_{22}\text{F}_2\text{N}_6\text{O}_2$ :

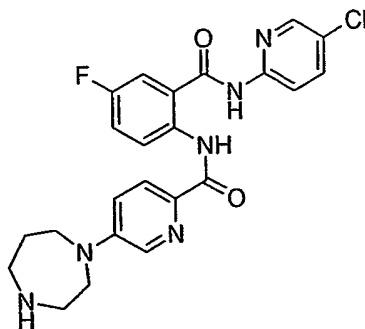
Calcd: C, 61.05; H, 4.90; N, 18.57;

Found: C, 60.85; H, 4.84; N, 18.40.

10

## Example 25

5-Fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyridin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.



15  $^1\text{H-NMR}$

ESI-MS, m/e 469.16 (M+1).

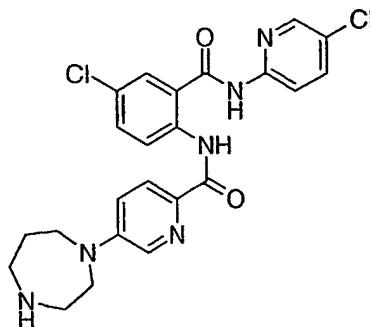
Also prepared were the hydrochloride and  
trihydrochloride salts.

20

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## Example 26

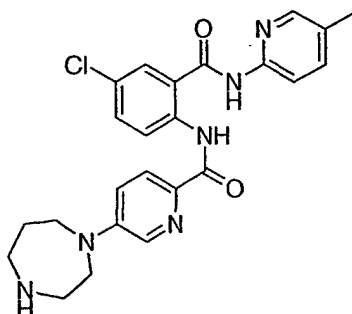
5-Chloro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyridin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

5  $^1\text{H-NMR}$ 

ESI-MS, m/e 483.35 (M-1).

## Example 27

5-Chloro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyridin-2-yl]-  
carbonylamino]-N-(5-methylpyridin-2-yl)benzamide.

 $^1\text{H-NMR}$ 

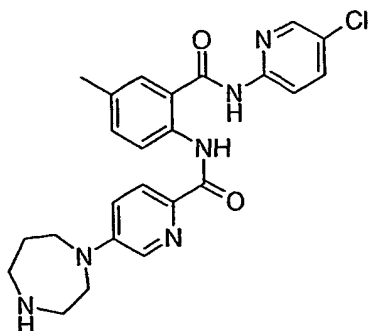
ESI-MS, m/e 465.19 (M+1).

15

## Example 28

2-[5-(Hexahydro-1,4-diazepin-1-yl)pyridin-2-yl]carbonyl-  
amino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.

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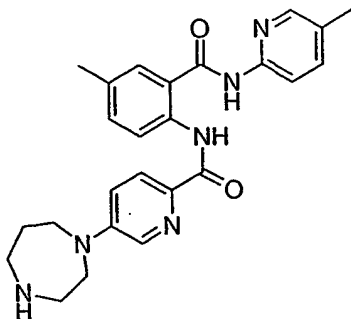
<sup>1</sup>H-NMR

ESI-MS, m/e 465.19 (M+1).

5

**Example 29**

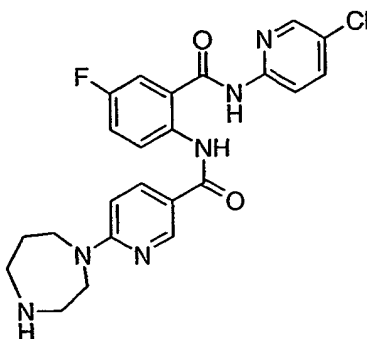
2-[5-(Hexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonyl-  
amino]-5-methyl-N-(5-methylpyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

10 ESI-MS, m/e 445.28 (M+1).

**Example 30**

5-Fluoro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridin-3-yl-  
carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.



15

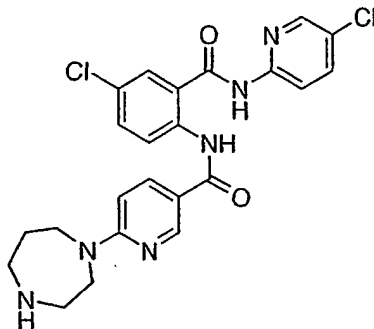
-110-

<sup>1</sup>H-NMR

ESI-MS, m/e 469.22 (M+1).

## Example 31

- 5    5-Chloro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridin-3-yl]pyridin-3-yl-carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

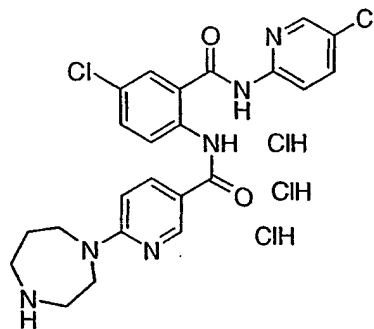
<sup>1</sup>H-NMR

ESI-MS, m/e 485.47 (M+1).

10

## Example 31a

- 5-Chloro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridin-3-yl]pyridin-3-yl-carbonylamino]-N-(5-chloropyridin-2-yl)benzamide  
Trihydrochloride.



15

<sup>1</sup>H-NMRFD-MS, m/e 484.21 (M<sup>+</sup>).Analysis for C<sub>23</sub>H<sub>22</sub>Cl<sub>2</sub>N<sub>6</sub>O<sub>2</sub>·3HCl·H<sub>2</sub>O:

Calcd:     C, 45.08; H, 4.44; N, 13.71;

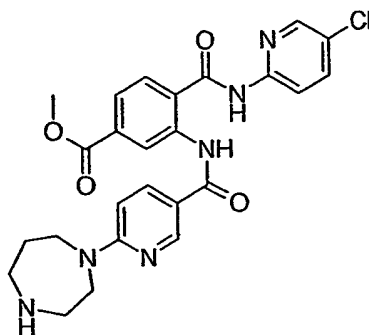
20

Found:     C, 45.13; H, 4.58; N, 13.36.

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**Example 32**

2-[6-(Hexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonyl-  
amino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.

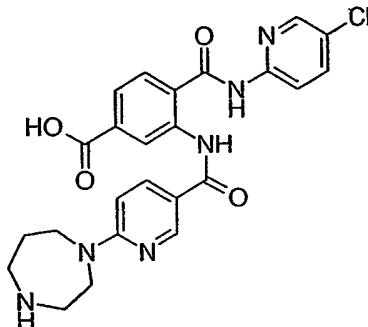


5  $^1\text{H-NMR}$

ESI-MS, m/e 509.28 (M+1).

**Example 33**

4-Carboxy-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridin-3-yl-  
10 carbonylamino]-N-(5-chloropyridin-2-yl)benzamide.



The above ester of Example 32 was hydrolyzed using a  
procedure similar to that of Example P11.

15

$^1\text{H-NMR}$

ESI-MS, m/e 495.09 (M+1).

**Preparation of Examples 34 - 87**

20 The following examples having a substituent on the  
4-position of the hexahydro-1,4-diazepin-1-yl moiety were



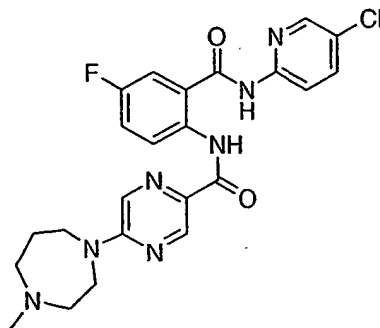
-112-

prepared from the corresponding 1-substituted hexahydro-1,4-diazepine and the requisite intermediate by using a procedure similar to that described for the preparation of Example P1, or as otherwise described.

5

**Example 34**

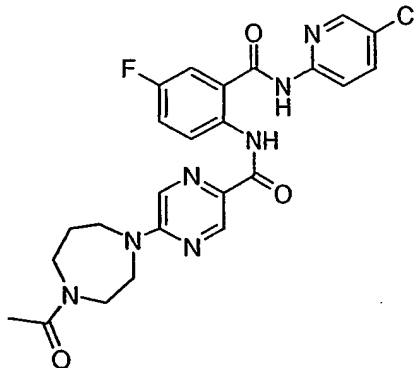
**5-Fluoro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

10  $^1\text{H-NMR}$ 

ESI-MS, m/e 484.48 (M+1).

**Example 35**

**2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyrazin-2-yl-carbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.**

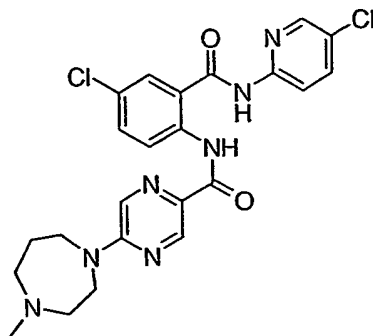
15  $^1\text{H-NMR}$ 

ESI-MS, m/e 512.38 (M+1).

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## Example 36

5-Chloro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

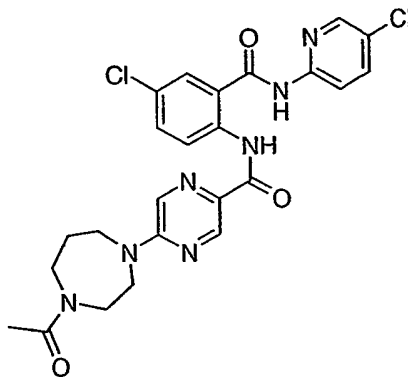


5  $^1\text{H}$ -NMR

ESI-MS, m/e 500.06 (M+1).

## Example 37

2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyrazin-2-yl-  
10 carbonylamino]-5-chloro-N-(5-chloropyridin-2-yl)benzamide.



$^1\text{H}$ -NMR

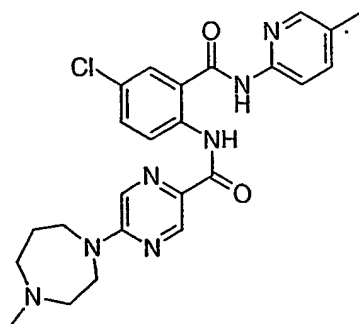
ESI-MS, m/e 526.04 (M-1).

15

## Example 38

5-Chloro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-methylpyridin-2-yl)benzamide.

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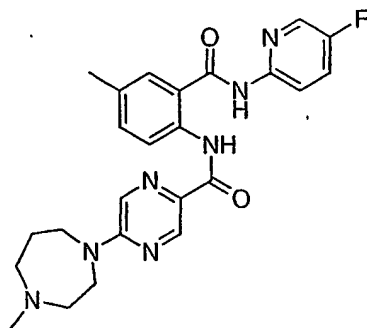
<sup>1</sup>H-NMR

ESI-MS, m/e 480.25 (M+1).

5

**Example 39**

5-Methyl-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-fluoropyridin-2-yl)benzamide.

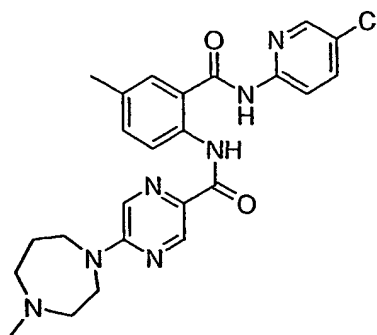
<sup>1</sup>H-NMR

10 ESI-MS, m/e 464.22 (M+1).

**Example 40**

5-Methyl-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

-115-

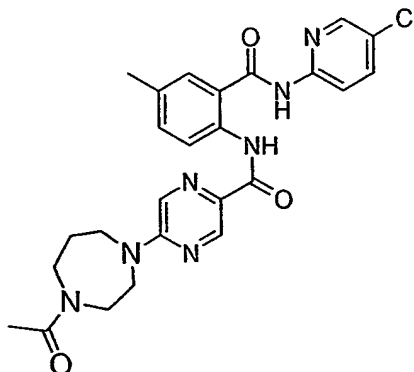
<sup>1</sup>H-NMR

ESI-MS, m/e 480.17 (M+1).

5

**Example 41**

2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyrazin-2-yl]-  
carbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.

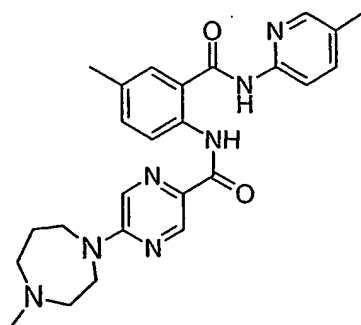
10 <sup>1</sup>H-NMR

ESI-MS, m/e 508.18 (M+1).

**Example 42**

5-Methyl-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-  
2-ylcarbonylamino]-N-(5-methylpyridin-2-yl)benzamide.

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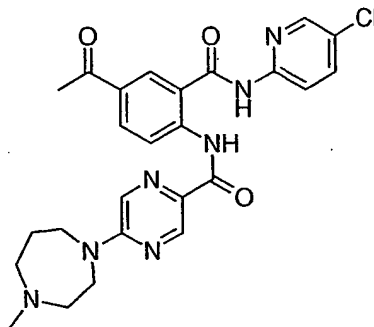
<sup>1</sup>H-NMR

ESI-MS, m/e 460.43 (M+1).

5

**Example 43**

5-Acetyl-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

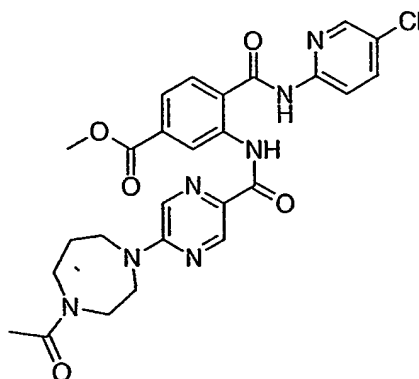
<sup>1</sup>H-NMR

10 ESI-MS, m/e 508.21 (M+1).

**Example 44**

2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-5-methoxycarbonyl-N-(5-chloropyridin-2-yl)-  
15 benzamide.

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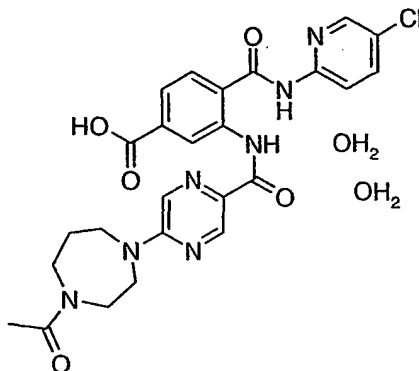
<sup>1</sup>H-NMR

ESI-MS, m/e 550.54 (M-1).

5

**Example 45**

**2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyrazin-2-yl-carbonylamino]-5-carboxy-N-(5-chloropyridin-2-yl)benzamide Dihydrate.**



10        The acid was prepared from the corresponding ester of Example 44, above, using a procedure similar to that of Example P11.

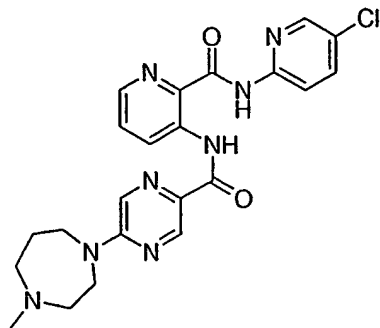
<sup>1</sup>H-NMR

15    ESI-MS, m/e 536.19 (M-1).

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## Example 46

3-[5-(4-Methylhexahydro-1,4-diazepin-1-yl)pyrazin-2-yl]-  
carbonylamino]-N-(5-chloropyridin-2-yl)pyridine-2-  
carboxamide.



5

<sup>1</sup>H-NMR

ESI-MS, m/e 467.31 (M+1).

Analysis for C<sub>22</sub>H<sub>23</sub>ClN<sub>8</sub>O<sub>2</sub>:

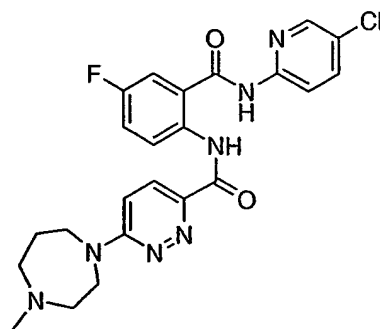
Calcd: C, 56.59; H, 4.97; N, 24.00;

10

Found: C, 56.16; H, 4.90; N, 23.58.

## Example 47

5-Fluoro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-  
pyridazin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-  
15 benzamide.

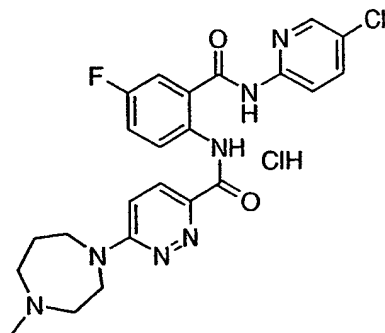
<sup>1</sup>H-NMR

ESI-MS, m/e 484.47 (M+1).

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**Example 47a**

5-Fluoro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-pyridazin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide Hydrochloride.



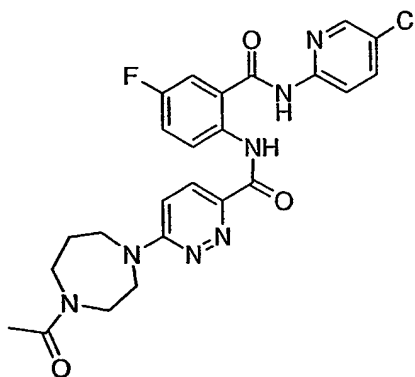
5

<sup>1</sup>H-NMR

ESI-MS, m/e 484.41 (M+1).

**Example 48**

10 2-[6-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyridazin-3-yl-carbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

ES-MS, m/e 510.32 (M-1).

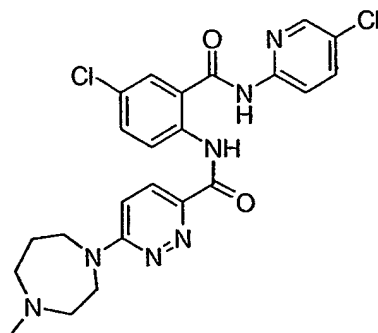
15

**Example 49**

5-Chloro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-pyridazin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.



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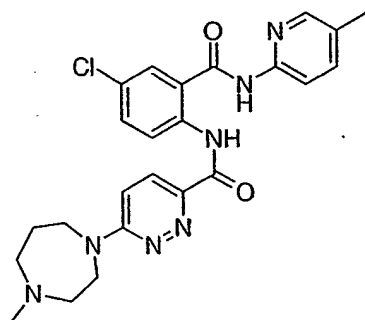
<sup>1</sup>H-NMR

ESI-MS, m/e 500.06 (M+1).

5

**Example 50**

**5-Chloro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-pyridazin-3-ylcarbonylamino]-N-(5-methylpyridin-2-yl)-benzamide.**

10 <sup>1</sup>H-NMR

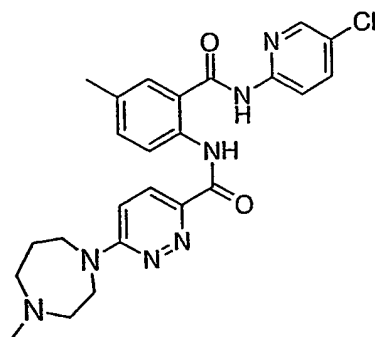
ESI-MS, m/e 480.18 (M+1).

**Example 51**

**5-Methyl-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-pyridazin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.**

15

-121-

<sup>1</sup>H-NMR

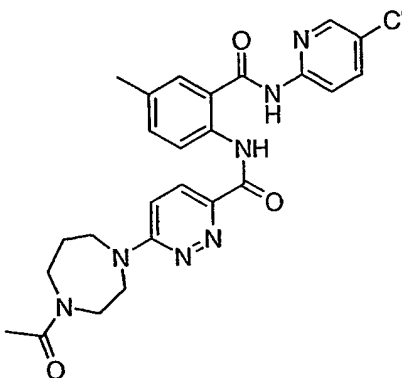
ESI-MS, m/e 480.14 (M+1).

Analysis for C<sub>24</sub>H<sub>26</sub>ClN<sub>7</sub>O<sub>2</sub>:

5            Calcd:      C, 60.06; H, 5.46; N, 20.43;  
              Found:     C, 59.66; H, 5.35; N, 19.99.

**Example 52**

2-[6-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyridazin-3-yl]-  
 10 carbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

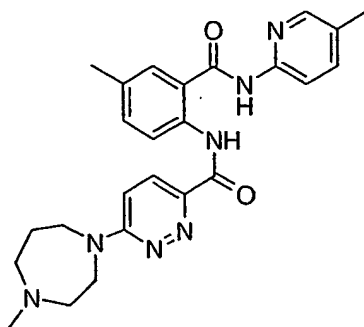
ESI-MS, m/e 508.17 (M+1).

15

**Example 53**

5-Methyl-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-  
 pyridazin-3-ylcarbonylamino]-N-(5-methylpyridin-2-yl)-  
 benzamide.

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<sup>1</sup>H-NMR

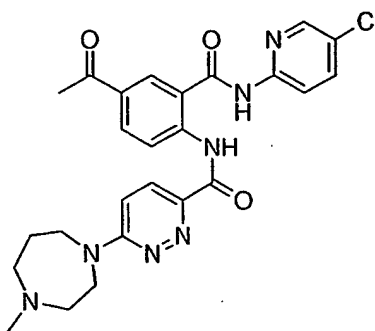
ESI-MS, m/e 460.40 (M+1).

Analysis for C<sub>25</sub>H<sub>29</sub>N<sub>7</sub>O<sub>2</sub>:

5	Calcd:	C, 65.34; H, 6.36; N, 21.34;
	Found:	C, 65.81; H, 6.35; N, 21.51.

**Example 54**

5-Acetyl-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)-  
 10 pyridazin-3-yl]carbonylamino-N-(5-chloropyridin-2-yl)-  
 benzamide.

<sup>1</sup>H-NMR

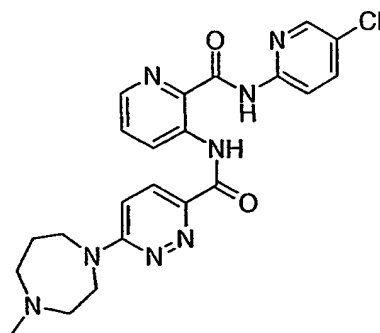
ESI-MS, m/e 506.14 (M-1).

15

**Example 55**

3-[6-(4-Methylhexahydro-1,4-diazepin-1-yl)pyridazin-3-yl]-  
 carbonylamino-N-(5-chloropyridin-2-yl)pyridine-2-  
 carboxamide.

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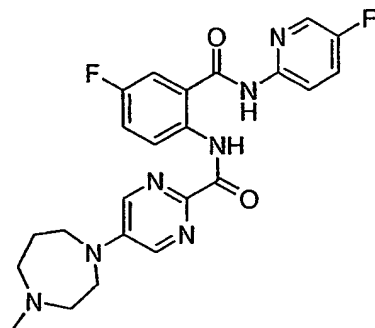
<sup>1</sup>H-NMR

ESI-MS, m/e 467.3 (M+1).

5

**Example 56**

**5-Fluoro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)-pyrimidin-2-ylcarbonylamino]-N-(5-fluoropyridin-2-yl)-benzamide.**

10 <sup>1</sup>H-NMR

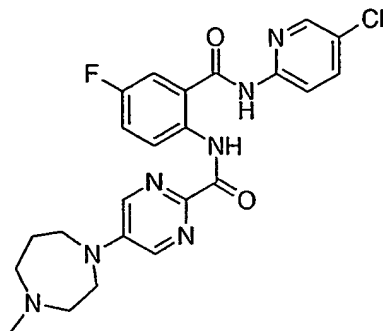
ESI-MS, m/e 466.34 (M-1).

**Example 57**

**5-Fluoro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)-pyrimidin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.**

15

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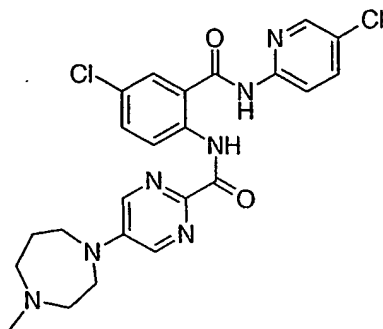
<sup>1</sup>H-NMR

ESI-MS, m/e 484.16 (M+1).

5

**Example 58**

**5-Chloro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)-pyrimidin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.**



10

<sup>1</sup>H-NMR

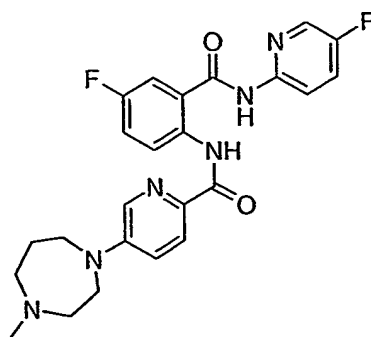
ESI-MS, m/e 500.13 (M+1).

15

**Example 59**

**5-Fluoro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyrimidin-2-ylcarbonylamino]-N-(5-fluoropyridin-2-yl)benzamide.**

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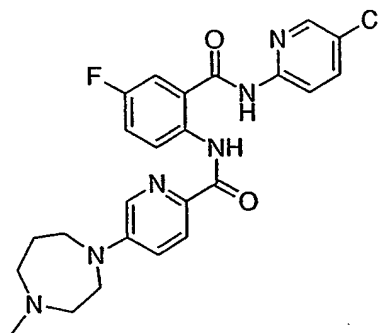
<sup>1</sup>H-NMR

ESI-MS, m/e 467.2 (M+1).

5

**Example 60**

**5-Fluoro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

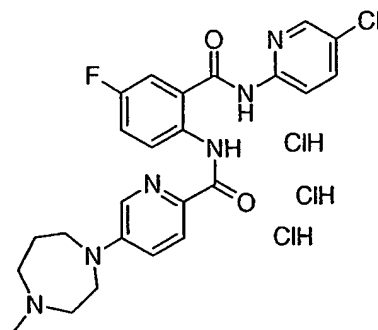
<sup>1</sup>H-NMR

10 ESI-MS, m/e 483.33 (M+1).

**Example 60a**

**5-Fluoro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide**  
15 **Trihydrochloride.**

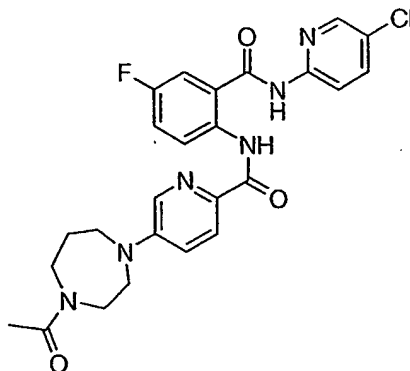
-126-

 $^1\text{H-NMR}$ ESI-MS,  $m/e$  481.24 ( $M+1$ ).

5

**Example 61**

2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyridin-2-yl-carbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.

 $^1\text{H-NMR}$ 10 ESI-MS,  $m/e$  509.24 ( $M-1$ ).Analysis for  $\text{C}_{25}\text{H}_{24}\text{ClFN}_6\text{O}_3$ :

Calcd: C, 58.77; H, 4.73; N, 16.45;

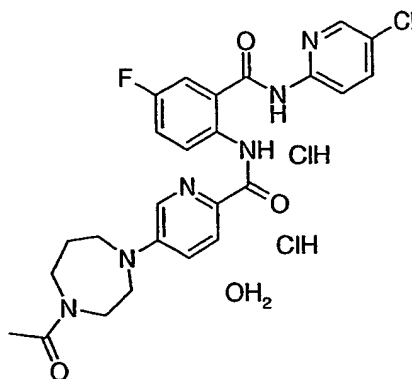
Found: C, 58.33; H, 4.82; N, 16.02.

15

**Example 61a**

2-[5-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyridin-2-yl-carbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide Dihydrochloride Hydrate.

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<sup>1</sup>H-NMR

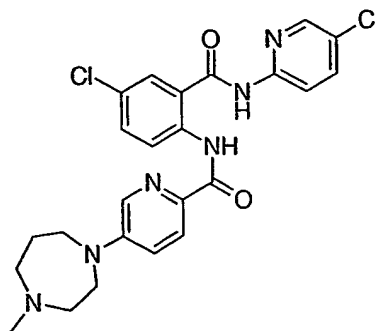
ESI-MS, m/e 509.21 (M-1).

Analysis for C<sub>25</sub>H<sub>24</sub>ClFN<sub>6</sub>O<sub>3</sub>·2HCl·H<sub>2</sub>O:

5	Calcd:	C, 49.89; H, 4.69; N, 13.96;
	Found:	C, 49.55; H, 4.23; N, 13.83.

**Example 62**

5-Chloro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-  
 10 2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

ESI-MS, m/e 499.18 (M+1).

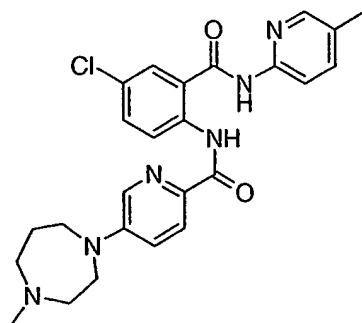
15

**Example 63**

5-Chloro-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-  
 2-ylcarbonylamino]-N-(5-methylpyridin-2-yl)benzamide.



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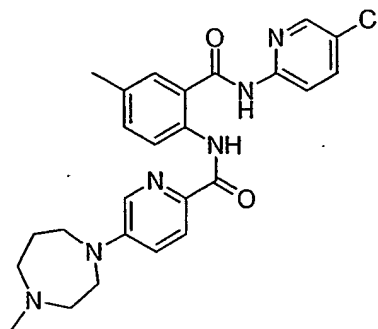
<sup>1</sup>H-NMR

ESI-MS, m/e 479.19 (M+1).

5

**Example 64**

5-Methyl-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

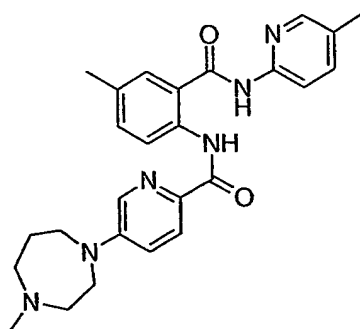
<sup>1</sup>H-NMR

10 ESI-MS, m/e 479.45 (M+1).

**Example 65**

5-Methyl-2-[5-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-N-(5-methylpyridin-2-yl)benzamide.

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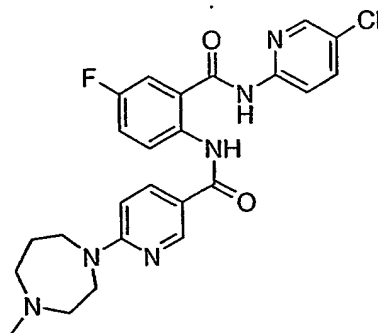
<sup>1</sup>H-NMR

ESI-MS, m/e 459.48 (M+1).

5

**Example 66**

**5-Fluoro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

<sup>1</sup>H-NMR

10 ESI-MS, m/e 483.35 (M+1).

Analysis for C<sub>24</sub>H<sub>24</sub>ClFN<sub>6</sub>O<sub>2</sub>:

Calcd: C, 59.69; H, 5.01; N, 17.40;

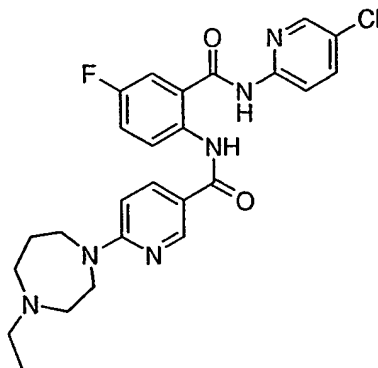
Found: C, 59.94; H, 4.91; N, 17.29.

15

**Example 67**

**5-Fluoro-2-[6-(4-ethylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

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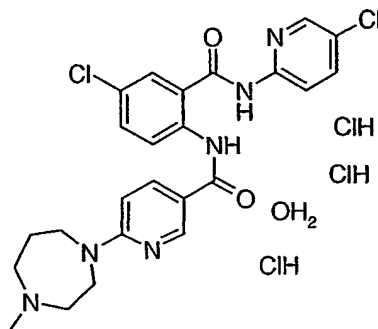
<sup>1</sup>H-NMR

ESI-MS, m/e 497.45 (M+1).

5

**Example 68**

**5-Chloro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide Trihydrochloride Hydrate.**

10 <sup>1</sup>H-NMR

ESI-MS, m/e 497.22 (M-1).

Analysis for C<sub>24</sub>H<sub>24</sub>Cl<sub>2</sub>N<sub>6</sub>O<sub>2</sub>·3HCl·H<sub>2</sub>O:

Calcd: C, 45.99; H, 4.66; N, 13.41;

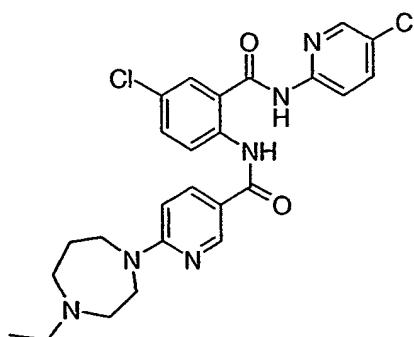
Found: C, 46.28; H, 4.49; N, 13.05.

15

**Example 69**

**5-Chloro-2-[6-(4-ethylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

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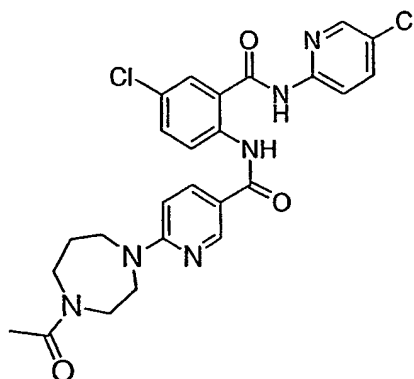
<sup>1</sup>H-NMR

ESI-MS, m/e 513.44 (M+1).

5

**Example 70**

2-[6-(4-Acetylhexahydro-1,4-diazepin-1-yl)pyridin-3-yl-carbonylamino]-5-chloro-N-(5-chloropyridin-2-yl)benzamide.

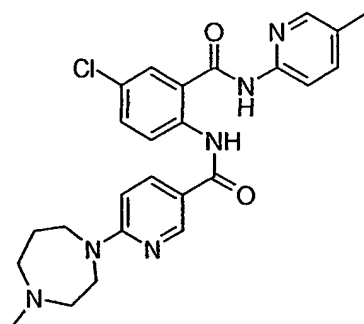
<sup>1</sup>H-NMR

10 ESI-MS, m/e 527.13 (M+1).

**Example 71**

5-Chloro-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-methylpyridin-2-yl)benzamide.

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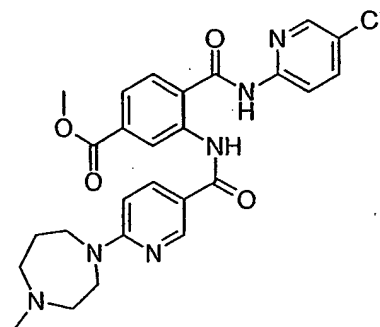
<sup>1</sup>H-NMR

ESI-MS, m/e 479.21 (M+1).

5

**Example 72**

**4-Methoxycarbonyl-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.**

10 <sup>1</sup>H-NMR

ESI-MS, m/e 523.19 (M+1).

Analysis for C<sub>26</sub>H<sub>27</sub>ClN<sub>6</sub>O<sub>4</sub>:

Calcd: C, 59.71; H, 5.20; N, 16.07;

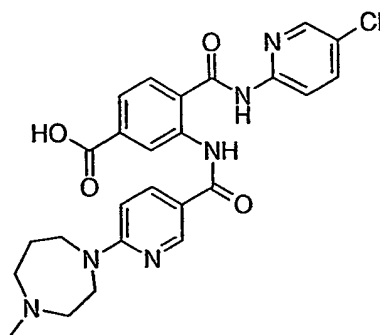
Found: C, 59.41; H, 5.17; N, 16.02.

15

**Example 73**

**4-Carboxy-2-[6-(4-methylhexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.**

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Using procedures similar to those of Examples 44 and 45 above, the corresponding ester was prepared and converted into the title acid.

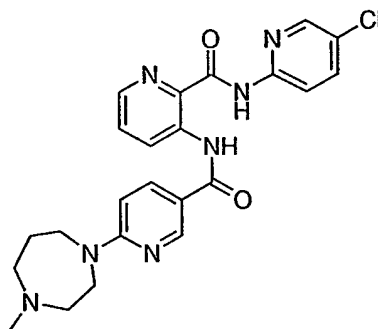
5

<sup>1</sup>H-NMR

ESI-MS, m/e 509.26 (M+1).

**Example 74**

- 10 3-[(4-Methylhexahydro-1,4-diazepin-1-yl)pyridin-3-yl-carbonylamino]-N-(5-chloropyridin-2-yl)pyridine-2-carboxamide.

<sup>1</sup>H-NMR

- 15 ESI-MS, m/e 466.21 (M+1).

Analysis for C<sub>23</sub>H<sub>24</sub>ClN<sub>7</sub>O<sub>2</sub>:

Calcd: C, 59.29; H, 5.19; N, 21.04;

Found: C, 59.02; H, 5.26; N, 20.80.

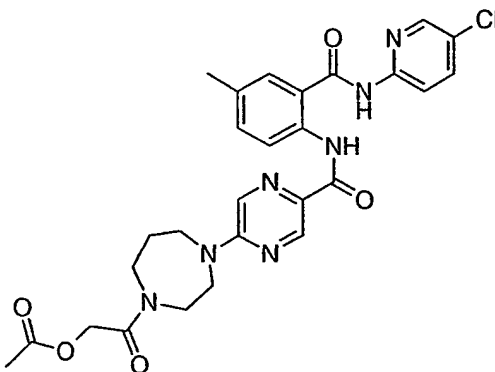
-134-

## Preparation of Examples 75 - 76

The following examples having an acetoxyacetyl group on the 4-position of the hexahydro-1,4-diazepin-1-yl moiety were prepared by acylating the corresponding hexahydro-1,4-diazepine described above using a procedure similar to that described for the preparation of Example 75, below.

## Example 75

2-[5-[4-(Acetoxyacetyl)hexahydro-1,4-diazepin-1-yl]pyrazin-2-yl]carbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)-benzamide.



To a suspension of 2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-yl]carbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide (Example 6, 0.932 g, 2 mmol) in methylene chloride was added triethyl amine (0.34 ml, 2.2 mmol) and acetoxyacetyl chloride (0.2867 g, 2.1 mmol). The reaction mixture was stirred overnight, and the solvent was evaporated. Water (5 mL) and ether (5 mL) were added, and the mixture was sonicated for five minutes. The solids were filtered, washed with water (3 mL), ether (5 mL) and dried. Yield = 0.780 g.

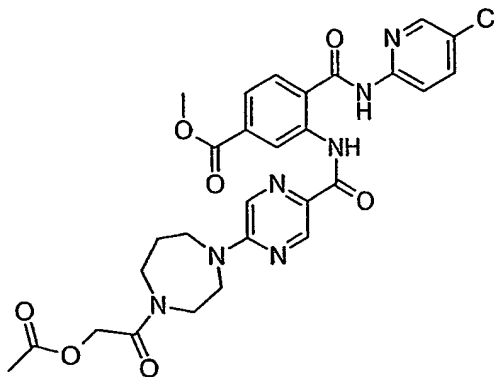
<sup>1</sup>H-NMR

ESI-MS, m/e 566.47 (M+1).

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**Example 76**

2-[5-[4-(Acetoxyacetyl)hexahydro-1,4-diazepin-1-yl]pyrazin-2-ylcarbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.



5

<sup>1</sup>H-NMR

ESI-MS, m/e 610.11 (M+1).

**Preparation of Examples 77 - 78**

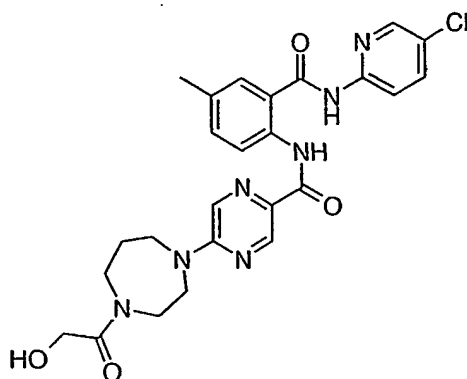
10       The following examples having a hydroxyacetyl group on the 4-position of the hexahydro-1,4-diazepin-1-yl moiety were prepared by hydrolyzing the acetoxyacetyl group on the 4-position of the hexahydro-1,4-diazepin-1-yl moiety of the corresponding compound described above using a procedure  
15       similar to that described for the preparation of Example 77, below.

**Example 77**

20       2-[5-[4-(2-Hydroxyacetyl)hexahydro-1,4-diazepin-1-yl]-pyrazin-2-ylcarbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.



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To a solution of 2-[5-[4-(acetoxymethyl)hexahydro-1,4-diazepin-1-yl]pyrazin-2-yl]carbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide (Example 86, 0.22 g) in  
 5 methanol (5 mL) was added potassium carbonate (0.1 g) and water (1 mL). The mixture was stirred overnight, the methanol was evaporated, and the resulting solution acidified to pH 5 with acetic acid. The solids were  
 10 filtered, washed with water (2 x 3 mL), ether (3 mL) and dried under vacuum. Yield = 0.19 g.

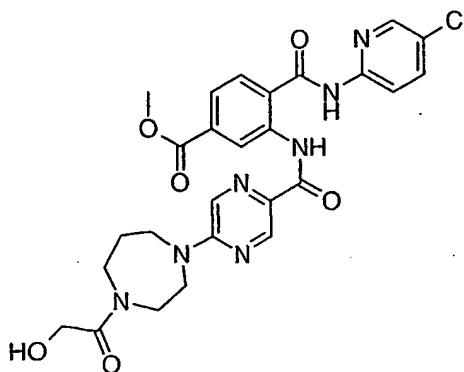
<sup>1</sup>H-NMR

ESI-MS, m/e 524.28 (M+1).

15

**Example 78**

**2-[5-[4-(2-Hydroxyacetyl)hexahydro-1,4-diazepin-1-yl]pyrazin-2-yl]carbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide.**



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<sup>1</sup>H-NMR

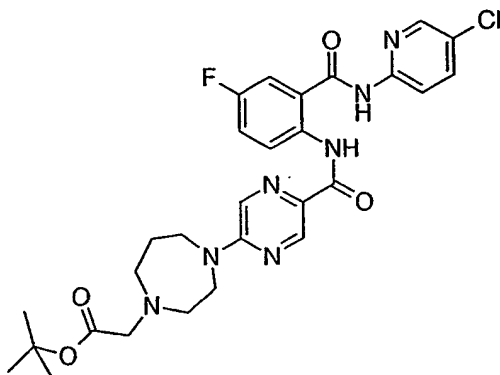
ESI+-MS, m/e 566.49 (M-1).

**Preparation of Examples 79 - 81**

5       The following examples having a t-butoxycarbonylmethyl group on the 4-position of the hexahydro-1,4-diazepin-1-yl moiety were prepared by alkylating the corresponding hexahydro-1,4-diazepine described above using a procedure similar to that described for the preparation of Example 79  
10 below.

**Example 79**

2-[5-[4-(t-Butoxycarbonylmethyl)hexahydro-1,4-diazepin-1-yl]pyrazin-2-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.  
15



To a solution of 5-fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide (Example 1, 0.3 g, 0.64 mmol) in methylene  
20 chloride was added methyltributylammonium chloride (1 mL), N,N-diisopropylethylamine (2.2 mL) and tert-butyl bromoacetate (2.496 g). The mixture was stirred at room temperature until a clear solution was obtained (24-48 h), diluted with methylene chloride (50 mL), washed with water  
25 (2 x 10 mL) and brine, dried over sodium sulfate, evaporated, and dried. Yield = 0.079 g.

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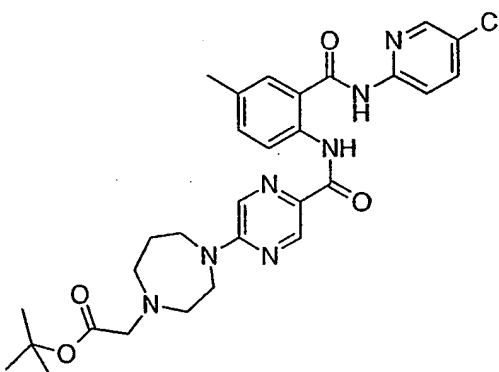
<sup>1</sup>H-NMR

ESI-MS, m/e 582 (M-1).

5

## Example 80

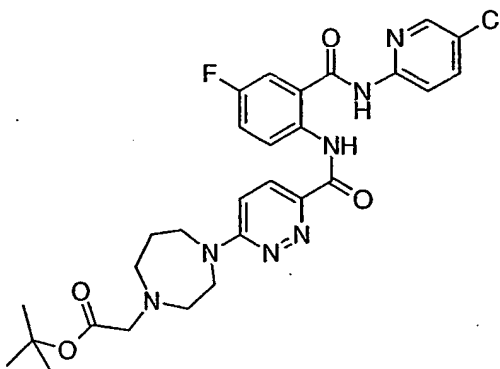
2-[5-[4-(t-Butoxycarbonylmethyl)hexahydro-1,4-diazepin-1-yl]pyrazin-2-ylcarbonylamino]-5-methyl-N-(5-chloropyridin-2-yl)benzamide.

10 <sup>1</sup>H-NMR

ESI-MS, m/e 578 (M-1).

## Example 81

2-[6-[4-(t-Butoxycarbonylmethyl)hexahydro-1,4-diazepin-1-yl]pyridazin-3-ylcarbonylamino]-5-fluoro-N-(5-chloropyridin-2-yl)benzamide.

<sup>1</sup>H-NMR

ESI-MS, m/e 582 (M-1).

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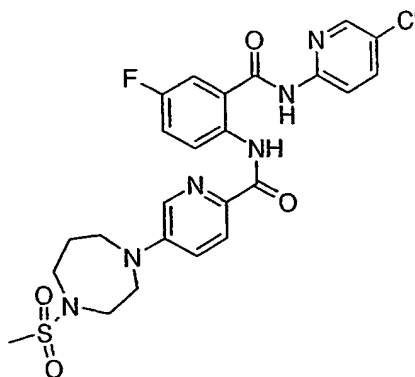
**Preparation of Examples 82 - 83**

The following examples having a sulfonyl group on the 4-position of the hexahydro-1,4-diazepin-1-yl moiety were prepared from the corresponding hexahydro-1,4-diazepine of Example 25 above using the indicated sulfonyl chloride and a procedure similar to that described for the acylation of Example 75, above.

10

**Example 82**

5-Fluoro-2-[5-(4-methylsulfonylhexahydro-1,4-diazepin-1-yl)-pyridin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)-benzamide.



15 Prepared using methanesulfonyl chloride.

<sup>1</sup>H-NMR

ESI-MS, m/e 545 (M-1).

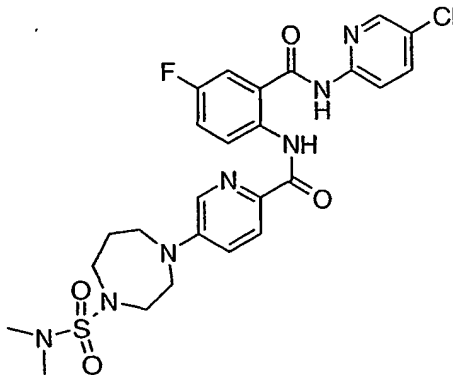
Analysis for C<sub>24</sub>H<sub>24</sub>ClFN<sub>6</sub>O<sub>4</sub>S:

20 Calcd: C, 52.70; H, 4.42; N, 15.36;  
Found: C, 52.54; H, 4.32; N, 15.27.

**Example 83**

5-Fluoro-2-[5-[4-(N,N-dimethylaminosulfonyl)hexahydro-1,4-diazepin-1-yl]pyridin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide.

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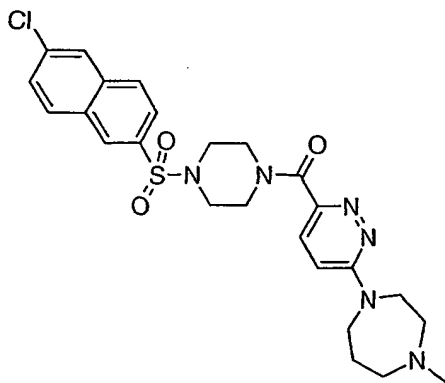
Prepared using dimethylaminosulfonyl chloride.

<sup>1</sup>H-NMR

5 ESI-MS, m/e 574.19 (M-1).

#### Example 84

Preparation of 1-(6-Chloronaphthalen-2-ylsulfonyl)-  
4-[6-(4-methylhexahydro-1,4-diazepin-1-yl)pyridazin-  
10 3-ylcarbonyl]piperazine Hemihydrate.



#### A. 6-Chloro-2-naphthalenesulfonic acid

6-Amino-2-naphthalenesulfonic acid (88.0 g, 0.4 mol) was  
15 suspended in 5 N HCl (200 mL) and water (150 mL) and cooled  
to 3 °C. A solution of sodium nitrite (27.0 g, 0.4 mol) in  
water (50 mL) was added dropwise over two hours. After one  
additional hour, the mixture was poured in several portions  
into a stirred suspension of copper(I) chloride (39.6 g,

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60.6 mmol) in 5 N HCl (200 mL). Considerable foaming occurred during this addition. After standing overnight at room temperature, the mixture was concentrated on a rotary evaporator to a brown solid that was then dried in a vacuum oven overnight at 100 °C to provide the acid (111.9 g).

B. 6-Chloro-2-naphthalenesulfonyl chloride

To a stirring solution of 6-chloro-2-naphthalene sulfonic acid (12 g) in DMF (40 mL) at 0 °C was added dropwise thionyl chloride (9 mL). After 3 h the mixture was poured over ice then extracted twice with methylene chloride. The combined organic extracts were washed with water and brine, and dried over sodium sulfate, then adsorbed onto silica and filtered through a pad of silica, eluting with 50% ethyl acetate: 50% hexanes. The solvents were then evaporated in vacuo to give 2.8 g of oil that crystallized on standing. The product was chromatographed on a (Biotage) silica column, eluting with ethyl acetate:hexanes (1:9), to yield 1.6 g pure product.

<sup>1</sup>H-NMR (CDCl<sub>3</sub>): δ (dd, 1H, 7.64, J=1,12), (m, 4H, 7.9-8.2), (s, 1H, 8,6);

FD-MS, m/e 259.9 (M<sup>+</sup>).

C. 1-Boc-4-(6-chloronaphthalen-2-ylsulfonyl)piperazine

To a stirring solution of N-Boc-piperazine (400 mg, 2.1 mmol) and triethylamine (1 mL, 7 mmol) in methylene chloride (5 mL) was added 6-chloro-2-naphthalenesulfonyl chloride (500 mg, 1.9 mmol). After 2 h the solution was washed with water, dried over sodium sulfate and evaporated.

The residue was chromatographed on a (Biotage) silica column, eluting with ethyl acetate:hexanes (2:8), to give 300 mg (38%).

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$^1\text{H-NMR}$  ( $\text{CDCl}_3$ ):  $\delta$  (s, 9H, 1.4), (m, 4H, 3.07), (m, 4H, 3.55), (dd, 1H, 7.55,  $J=1,12$ ), (dd, 1H, 7.75,  $J=1,12$ ), (m, 4H, 7.9), (s, 1H, 8.3),

FD-MS,  $m/e$  410.1 ( $\text{M}^+$ );

5 IR (chloroform) carbonyl  $1691\text{ cm}^{-1}$ .

Anal.

Calcd: C, 55.54; H, 5.64; N, 6.82; Cl, 8.63;

Found: C, 55.71; H, 5.76; N, 6.85; Cl, 8.76.

10 D. 1-(6-chloronaphthalen-2-ylsulfonyl)piperazine

To a stirring suspension of 1-Boc-4-(6-chloronaphthalen-2-ylsulfonyl)piperazine (2.8g, 6.8 mmol) in dioxane (50 mL) was added 4 M HCl in dioxane (5 mL, 40 mmol). After stirring overnight at room temperature, the  
15 solvent was evaporated in vacuo, and the residue was dissolved in water. The aqueous phase was made basic with 5 N NaOH and extracted twice with ethyl acetate. The combined extracts were washed with water and brine, then dried over sodium sulfate and evaporated to 2.1 g (100%)

20 solid.

$^1\text{H-NMR}$  ( $\text{DMSO}-d_6$ ):  $\delta$  (m, 4H, 2.71), (m, 4H, 2.86), (dd, 1H, 7.7,  $J=1, 10$ ), (dd, 1H, 7.8,  $J=1, 10$ ), (d, 1H, 8.16,  $J=10$ ), (s, 1H, 8.22), (d, 1H, 8.25,  $J=10$ ), (s, 1H, 8.48);

25 MS 311.2 ( $\text{M}+1$ ).

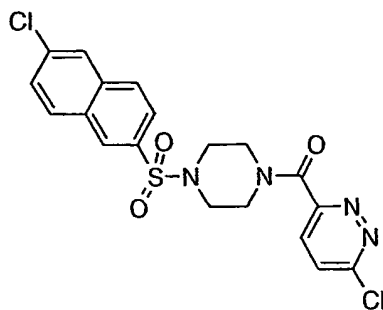
Anal.

Calcd: C, 54.10; H, 4.86; N, 9.01; Cl, 11.41;

Found: C, 54.20; H, 4.88; N, 8.85; Cl, 11.66.

30 E. 1-(6-Chloronaphthalene-2-sulfonyl)-4-(6-chloropyridazin-3-ylcarbonyl)piperazine.

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To a solution of 1-(6-chloronaphthalen-2-ylsulfonyl)-  
piperazine (0.450 g, 1.45 mmol) in methylene chloride (100  
5 mL) and pyridine (0.154 mL) was added dropwise 6-chloro-  
pyridazine-3-carbonyl chloride (1.74 mmol). After the  
addition of the acid chloride, pyridine (0.154 mL) was  
added, and the reaction mixture was stirred overnight. The  
reaction mixture was diluted with chloroform (500 mL),  
10 washed with saturated sodium bicarbonate (200 mL), water  
(200 mL), and brine and dried over  $\text{MgSO}_4$ . After filtration  
and evaporation of the solvent, trituration of the residue  
with ethyl acetate and filtration gave the product as a  
white powder (0.5 g, 76%)

15

 $^1\text{H}$ -NMRESI-MS,  $m/e$  451.02 ( $M+1$ ).

F. 1-(6-Chloronaphthalen-2-ylsulfonyl)-4-[6-(4-methyl-  
20 hexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonyl]-  
piperazine Hemihydrate.

A mixture of 1-(6-chloronaphthalene-2-sulfonyl)-  
4-(6-chloropyridazin-3-ylcarbonyl)piperazine (0.2 g, 0.443  
mmol), 1-methylhexahydro-1,4-diazepine (0.166 mL, 1.33 mmol)  
25 and pyridine (0.11 mL, 1.33 mmol) in DMSO (5 mL) was heated  
in a sealed tube at 80 °C overnight. The reaction mixture  
was cooled to room temperature, diluted with ethyl acetate  
(500 mL), washed with saturated sodium bicarbonate (200 mL),



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water (2 X 150 mL) and brine, and dried over sodium sulfate. After filtration and evaporation of the solvent, the residue was purified by flash chromatography over silica, eluting with 5-7% methanol/methylene chloride, to afford the title  
5 compound (0.1 g, 43%).

<sup>1</sup>H-NMR

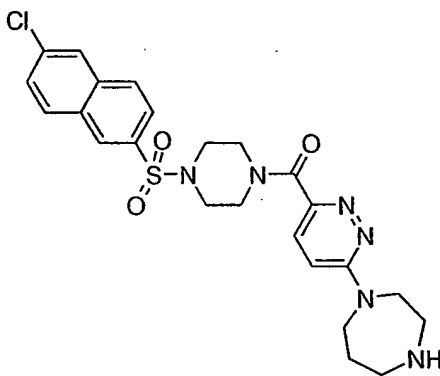
ESI-MS, m/e 529.13 (M+1).

Analysis for C<sub>25</sub>H<sub>29</sub>ClN<sub>6</sub>O<sub>3</sub>S 0.5 H<sub>2</sub>O:

10 Calcd: C, 55.81; H, 5.62; N, 15.62;  
Found: C, 55.89; H, 5.39; N, 15.19.

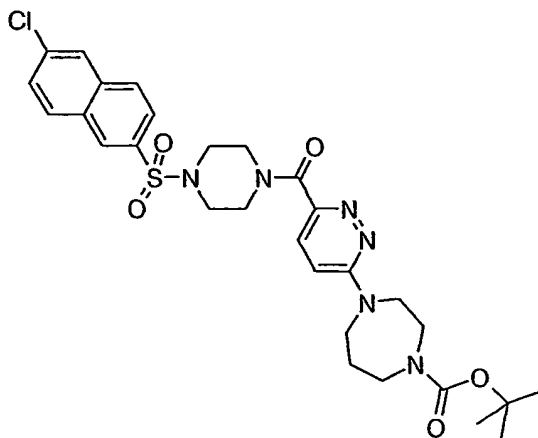
## Example 85

Preparation of 1-(6-Chloronaphthalen-2-ylsulfonyl)-  
15 4-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonyl]-  
piperazine.



A. 1-[6-(4-t-Butoxycarbonylhexahydro-1,4-diazepin-1-yl)-  
20 pyridazin-3-ylcarbonyl]-4-(6-chloronaphthalen-2-ylsulfonyl)-  
piperazine.

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Using 1-Boc-hexahydro-1,4-diazepine and a similar procedure to that of Example 101-F, the N-protected compound was obtained.

5

<sup>1</sup>H-NMR

ESI-MS, m/e 615.33 (M+1).

10 B. 1-(6-Chloronaphthalen-2-ylsulfonyl)-4-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonyl]piperazine.

To a solution of 1-[6-(4-*t*-butoxycarbonylhexahydro-1,4-diazepin-1-yl)pyridazin-3-ylcarbonyl]-4-(6-chloronaphthalen-2-ylsulfonyl)piperazine (0.320 g, 0.52 mmol) in methylene chloride (10 mL) was added trifluoroacetic acid (2 mL). The  
15 reaction mixture was stirred overnight at room temperature, and the solvent removed by evaporation. The residue was purified using a SCX column to afford the title product (0.230 g, 86%).

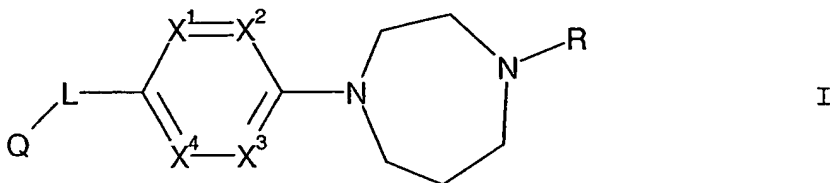
20 <sup>1</sup>H-NMR

ESI-MS, m/e 515.035 (M+1).

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What is claimed is:

1. A compound of formula I,

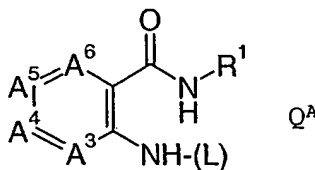


5

or a pharmaceutically acceptable salt thereof, wherein

L is carbonyl or methylene and Q (showing L at its point of attachment) is a residue of formula Q<sup>A</sup>,

10



in which

A<sup>3</sup>, A<sup>4</sup>, A<sup>5</sup> and A<sup>6</sup>, together with the two carbons to which they are attached, complete a substituted benzene in which A<sup>3</sup> is CR<sup>3</sup>, A<sup>4</sup> is CR<sup>4</sup>, A<sup>5</sup> is CR<sup>5</sup>, and A<sup>6</sup> is CR<sup>6</sup>; wherein

R<sup>3</sup> is hydrogen, fluoro, chloro, methyl, methoxy, hydroxy or carboxy;

one of R<sup>4</sup> and R<sup>5</sup> is hydrogen, (1-4C)alkyl, halo, trifluoromethyl, trifluoromethoxy, cyano, hydroxymethyl, (1-3C)acyl, R<sup>f</sup>O-, R<sup>f</sup>O<sub>2</sub>C-, R<sup>f</sup>O<sub>2</sub>C-CH<sub>2</sub>-, R<sup>f</sup>O<sub>2</sub>C-CH<sub>2</sub>-O-, methylthio or R<sup>g</sup>NH-;

the other of R<sup>4</sup> and R<sup>5</sup> is hydrogen, halo or methyl; and

R<sup>6</sup> is hydrogen, fluoro, chloro, methyl or methoxy;

in which R<sup>f</sup> is hydrogen, (1-4C)alkyl or benzyl; R<sup>g</sup> is hydrogen, (1-3C)acyl, trifluoroacetyl, methoxyacetyl, or R<sup>h</sup>SO<sub>h</sub>- (wherein h is 1 or 2); and R<sup>h</sup> is (1-4C)alkyl,

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trifluoromethyl, phenyl, amino, methylamino or dimethylamino; or

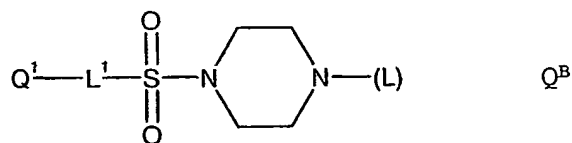
A<sup>3</sup>, A<sup>4</sup>, A<sup>5</sup> and A<sup>6</sup>, together with the two carbons to which they are attached, complete a substituted  
 5 heteroaromatic ring in which one of A<sup>3</sup>, A<sup>4</sup>, A<sup>5</sup> and A<sup>6</sup> is N, and each of the others is CR<sup>3</sup>, CR<sup>4</sup>, CR<sup>5</sup> or CR<sup>6</sup>, respectively; wherein

each of R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> and R<sup>6</sup> is independently hydrogen or methyl, or one of R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> and R<sup>6</sup> attached to a carbon  
 10 which is not bonded to an N-atom is chloro and the others are hydrogen;

R<sup>1</sup> is 2-pyridinyl (which may bear a methyl, methoxy, methylthio, fluoro or chloro substituent at the 5-position), or R<sup>1</sup> is 3-pyridinyl (which may bear a methyl, fluoro or  
 15 chloro substituent at the 6-position), or R<sup>1</sup> is phenyl (which may bear one, two or three substituents at the 3-, 4- or 5-position(s) independently selected from halo, cyano, carbamoyl, methyl, methoxy, difluoromethoxy, hydroxymethyl, formyl, vinyl, amino, hydroxy and 3,4-methylenedioxy; and in  
 20 addition the phenyl may bear a 2-chloro or 2-fluoro substituent), or R<sup>1</sup> is 6-indolyl (which may bear a chloro or methyl substituent at the 3-position); or

L is carbonyl and Q (showing L at its point of attachment) is a residue of formula Q<sup>B</sup>,

25



wherein:

Q<sup>1</sup> is phenyl, benzo[b]thiophen-2-yl or naphthalen-2-yl  
 30 any of which may bear one or more halo, trifluoromethyl, methoxy or methyl substituents;

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L<sup>1</sup> is a direct bond, methylene, ethylene or ethen-1,2-diyl;

one or two of X<sup>1</sup>, X<sup>2</sup>, X<sup>3</sup> and X<sup>4</sup> is N; and each of the others of X<sup>1</sup>, X<sup>2</sup>, X<sup>3</sup> and X<sup>4</sup> is CH; and

5 R is hydrogen, (1-3C)alkyl, (1-3C)acyl, acetyloxy-acetyl, aminoacetyl, hydroxyacetyl, {(1-4C)alkoxy}carbonyl, {(1-4C)alkoxy}carbonylmethyl, R<sup>a</sup>R<sup>b</sup>N-CO- or R<sup>j</sup>SO<sub>j</sub>-, wherein each of R<sup>a</sup> and R<sup>b</sup> is independently hydrogen or (1-3C)alkyl, or R<sup>a</sup>R<sup>b</sup>N- is 1-azetidiny, 1-pyrrolidinyl, 1-piperidinyl,  
10 4-morpholinyl or 4-thiomorpholinyl; j is 1 or 2; and R<sup>j</sup> is (1-4C)alkyl, trifluoromethyl, amino, methylamino or dimethylamino.

2. The compound, or salt thereof, of Claim 1 wherein  
15 halo is fluoro, chloro or bromo; (1-3C)alkyl is methyl, ethyl, propyl or isopropyl; (1-4C)alkyl is methyl, ethyl, propyl, isopropyl, butyl, isobutyl or t-butyl; (1-4C)alkoxy is methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy or t-butoxy; and (1-3C)acyl is formyl, acetyl or propionyl.

20

3. The compound, or salt thereof, of Claim 1 or 2 wherein

when Q is Q<sup>A</sup>,

R<sup>3</sup> is hydrogen;

25 one of R<sup>4</sup> and R<sup>5</sup> is hydrogen, (1-4C)alkyl, halo, trifluoromethyl, trifluoromethoxy, cyano, hydroxymethyl, (1-3C)acyl, R<sup>f</sup>O-, R<sup>f</sup>O<sub>2</sub>C-, R<sup>f</sup>O<sub>2</sub>C-CH<sub>2</sub>-, R<sup>f</sup>O<sub>2</sub>C-CH<sub>2</sub>-O-, methylthio or R<sup>g</sup>NH- in which R<sup>g</sup> is hydrogen, (1-3C)acyl, or R<sup>h</sup>SO<sub>2</sub>-; and R<sup>h</sup> is (1-4C)alkyl, trifluoromethyl, amino,  
30 methylamino or dimethylamino;

the other of R<sup>4</sup> and R<sup>5</sup> is hydrogen, halo or methyl; and R<sup>6</sup> is hydrogen;

or

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A<sup>6</sup> is N, and each of the others is CR<sup>3</sup>, CR<sup>4</sup> and CR<sup>5</sup>, respectively, in which R<sup>3</sup> and R<sup>4</sup> is each hydrogen and R<sup>5</sup> is hydrogen or methyl; and

when Q is Q<sup>B</sup>, Q<sup>1</sup>L<sup>1</sup> is trans-styryl (which may bear one  
5 or more halo, methoxy or methyl substituents on the aromatic ring), benzo[b]thiophen-2-yl (which may bear one or more halo, methoxy or methyl substituents at the 5- and/or 6-position) or naphthalen-2-yl (which may bear one or more halo, methoxy or methyl substituents at the 6- and/or  
10 7-position); and

R is hydrogen, (1-3C)alkyl, (1-3C)acyl, acetyloxy-acetyl, hydroxyacetyl, methoxycarbonyl, ethoxycarbonyl, ((1-4C)alkoxy)carbonylmethyl, R<sup>a</sup>R<sup>b</sup>N-CO- or R<sup>j</sup>SO<sub>2</sub>-, wherein each of R<sup>a</sup> and R<sup>b</sup> is independently hydrogen or (1-3C)alkyl,  
15 or R<sup>a</sup>R<sup>b</sup>N- is 1-azetidiny, 1-pyrrolidinyl, 1-piperidinyl, 4-morpholinyl or 4-thiomorpholinyl; and R<sup>j</sup> is (1-4C)alkyl, trifluoromethyl, amino, methylamino or dimethylamino.

4. The compound, or salt thereof, of Claim 1, 2 or 3  
20 wherein

when Q is Q<sup>A</sup>,

A<sup>3</sup> is CR<sup>3</sup>, A<sup>4</sup> is CR<sup>4</sup>, A<sup>5</sup> is CR<sup>5</sup>, and A<sup>6</sup> is CR<sup>6</sup>; wherein each of R<sup>3</sup>, R<sup>4</sup> and R<sup>6</sup> is hydrogen and R<sup>5</sup> is fluoro, chloro, methyl, acetyl, methoxycarbonyl or carboxy; or each of R<sup>3</sup>,  
25 R<sup>5</sup> and R<sup>6</sup> is hydrogen and R<sup>4</sup> is methoxycarbonyl or carboxy; or each of R<sup>3</sup> and R<sup>6</sup> is hydrogen and each of R<sup>4</sup> and R<sup>5</sup> is fluoro; or

A<sup>6</sup> is N, and each of A<sup>3</sup>, A<sup>4</sup> and A<sup>5</sup> is CH; and

R<sup>1</sup> is 2-pyridinyl which bears a fluoro, chloro or  
30 methyl substituent at the 5-position; and

when Q is Q<sup>B</sup>,

Q<sup>1</sup> is 6-chloronaphthalen-2-yl and L<sup>1</sup> is a direct bond; each of X<sup>1</sup> and X<sup>2</sup> is N; and each of X<sup>3</sup> and X<sup>4</sup> is CH; or each of X<sup>1</sup> and X<sup>3</sup> is N; and each of X<sup>2</sup> and X<sup>4</sup> is CH; or

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each of  $X^1$  and  $X^4$  is N; and each of  $X^3$  and  $X^4$  is CH; or  
 $X^1$  is N and each of  $X^2$ ,  $X^3$  and  $X^4$  is CH; or  
 $X^2$  is N and each of  $X^1$ ,  $X^3$  and  $X^4$  is CH; and

R is hydrogen, methyl, ethyl, acetyl, acetoxycetyl,  
5 hydroxyacetyl, t-butoxycarbonylmethyl, methylsulfonyl or  
dimethylaminosulfonyl.

5. The compound, or salt thereof, of any one of  
Claims 1-4 wherein Q is  $Q^A$ .

10

6. The compound, or salt thereof, of Claim 1 wherein  
Q is  $Q^A$ ;

L is carbonyl;

$A^3$  is  $CR^3$ ,  $A^4$  is  $CR^4$ ,  $A^5$  is  $CR^5$ , and  $A^6$  is  $CR^6$ ; wherein  
15 each of  $R^3$ ,  $R^4$  and  $R^6$  is hydrogen and  $R^5$  is fluoro, chloro,  
methyl, acetyl, methoxycarbonyl or carboxy; or each of  $R^3$ ,  
 $R^5$  and  $R^6$  is hydrogen and  $R^4$  is methoxycarbonyl or carboxy;

$R^1$  is 2-pyridinyl which bears a fluoro, chloro or  
methyl substituent at the 5-position; and

20 each of  $X^1$  and  $X^3$  is N; and each of  $X^2$  and  $X^4$  is CH; or  
each of  $X^1$  and  $X^4$  is N; and each of  $X^3$  and  $X^4$  is CH; or  
 $X^1$  is N and each of  $X^2$ ,  $X^3$  and  $X^4$  is CH; or  
 $X^2$  is N and each of  $X^1$ ,  $X^3$  and  $X^4$  is CH; and

R is hydrogen, methyl, ethyl, acetyl, acetoxycetyl,  
25 hydroxyacetyl, methylsulfonyl or dimethylaminosulfonyl.

7. The compound of Claim 1 which is selected from

- a. 5-fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrazin-  
2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide;  
30 b. 5-fluoro-2-[6-(hexahydro-1,4-diazepin-1-yl)pyridazin-  
3-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide;  
c. 5-fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyrimidin-  
2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide;

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- d. 5-fluoro-2-[5-(hexahydro-1,4-diazepin-1-yl)pyridin-2-ylcarbonylamino]-N-(5-chloropyridin-2-yl)benzamide; and  
e. 2-[6-(hexahydro-1,4-diazepin-1-yl)pyridin-3-ylcarbonylamino]-4-methoxycarbonyl-N-(5-chloropyridin-2-yl)benzamide,  
5 or a pharmaceutically acceptable salt thereof.

8. The compound, or salt thereof, of Claim 4 wherein Q is Q<sup>B</sup>.

- 10 9. The compound, or salt thereof, of Claim 8 wherein each of X<sup>1</sup> and X<sup>2</sup> is N and each of X<sup>3</sup> and X<sup>4</sup> is CH, and R is hydrogen or methyl.

10. The pharmaceutically acceptable salt of any of  
15 Claims 1-9 which is the acid addition salt of a basic compound of formula I with an inorganic or organic acid which affords a physiologically acceptable anion or which is the salt formed by an acidic compound of formula I with a base which affords a physiologically acceptable cation.

20

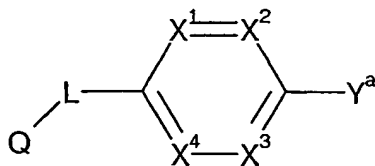
11. A pharmaceutical formulation comprising in association with a pharmaceutically acceptable carrier, diluent or excipient, a compound of formula I (or a pharmaceutically acceptable salt thereof) as provided in any  
25 of Claims 1-10.

12. A process for preparing a compound of formula I, or a pharmaceutically acceptable salt thereof, as provided in any of Claims 1-10, wherein a functional group of a  
30 starting material which is not involved in the indicated process may be in a form in which the functional group is protected using a protecting group, which comprises:

(A) substituting the group Y<sup>a</sup> of a compound of formula II,

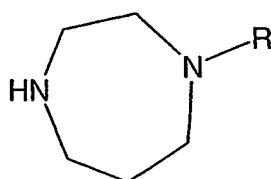


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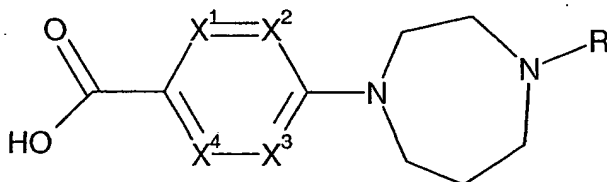
II

in which  $Y^a$  is a leaving group for nucleophilic aromatic  
 5 substitution, using an amine of formula III;



III

(B) for a compound of formula I in which L is  
 10 carbonyl, acylating an amine of formula Q-H using a  
 corresponding acid of formula IV,



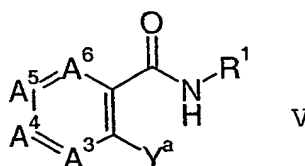
IV

15 or an activated derivative thereof;

(C) for a compound of formula I in which R is not  
 hydrogen, substituting the nitrogen of a corresponding  
 compound in which R is hydrogen using a conventional  
 procedure;

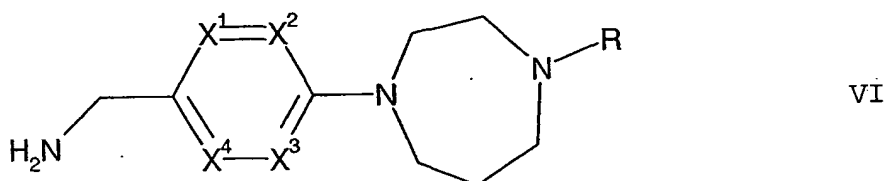
20 (D) for a compound of formula I in which L is  
 methylene and Q is  $Q^A$ , substituting the group  $Y^a$  of a  
 compound of formula V

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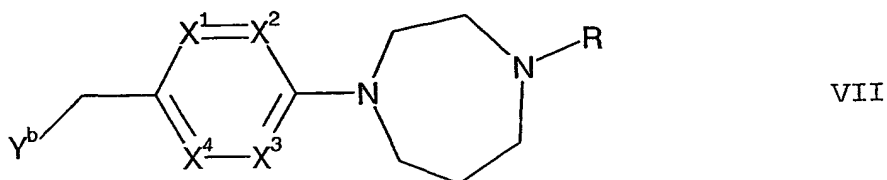
in which  $Y^a$  is a leaving group for nucleophilic aromatic substitution with an amine of formula VI; or

5



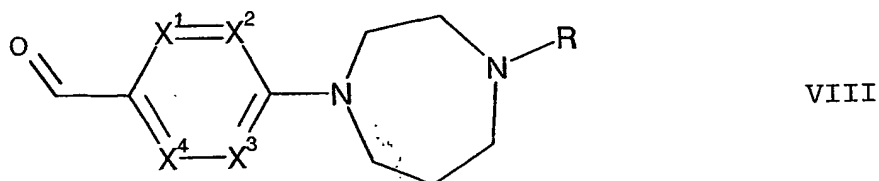
alkylating an amine of formula Q-H directly, using a compound of formula VII,

10



in which  $Y^b$  is a leaving group for nucleophilic substitution, or indirectly by reductive alkylation using an aldehyde of formula VIII;

15



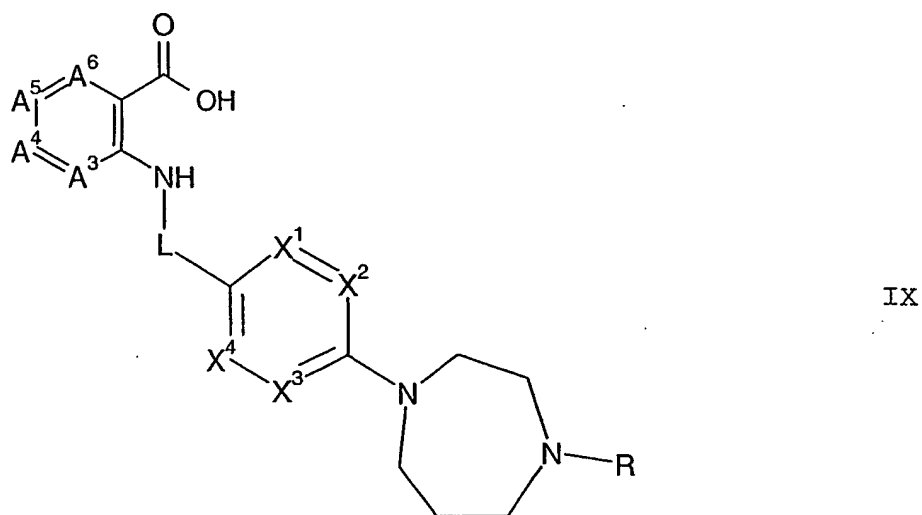
or

20

(E) for a compound of formula I in which Q is  $Q^A$ , acylating an amine of formula  $H_2N-R^1$ , or a deprotonated

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derivative thereof, using an acid of formula IX or an activated derivative thereof,



5

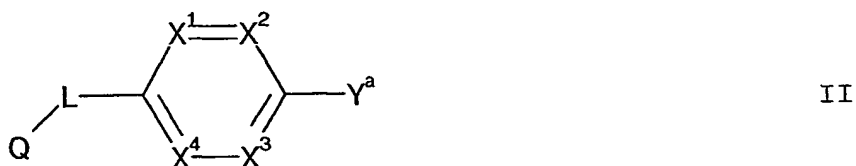
whereafter, for any of the above procedures, when a functional group of a starting material is protected using a protecting group, removing the protecting group;

whereafter, for any of the above procedures, when a  
 10 pharmaceutically acceptable salt of a compound of formula I is required, it is obtained by reacting the basic form of a basic compound of formula I with an acid affording a physiologically acceptable counterion or the acidic form of an acidic compound of formula I with a base affording a  
 15 physiologically acceptable counterion or by any other conventional procedure;

and wherein, unless otherwise specified, Q, L, X<sup>1</sup>-X<sup>4</sup>, and R have any of the values defined in any of Claims 1-10.

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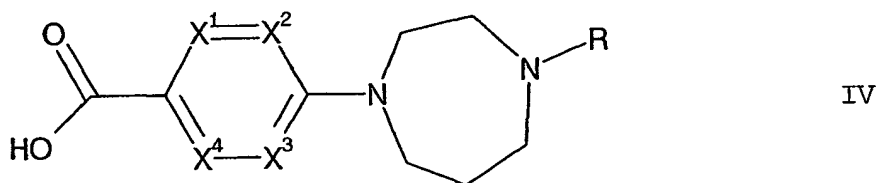
13. A compound of formula II,



5 in which  $Y^a$  is a leaving group for nucleophilic aromatic substitution and Q, L and  $X^1$ - $X^4$  have any of the values defined in any of Claims 1-9, or a derivative thereof in which a functional group other than  $Y^a$  is protected using a protecting group.

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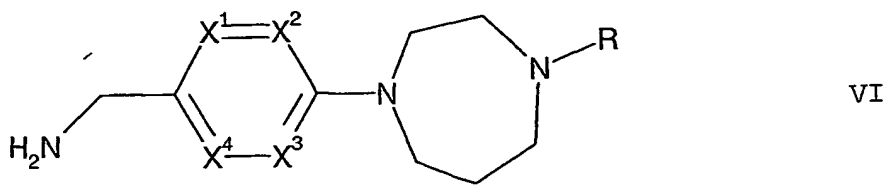
14. An acid of formula IV,



15 or an activated derivative thereof, or a salt of the acid or activated derivative, in which  $X^1$ - $X^4$ , and R have any of the values defined in any of Claims 1-9, or a derivative thereof in which a functional group other than the carboxy group, or activated derivative thereof, is protected using a

20 protecting group.

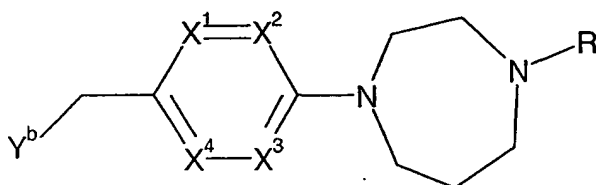
15. An amine of formula VI,



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or a salt thereof;

or a compound of formula VII,



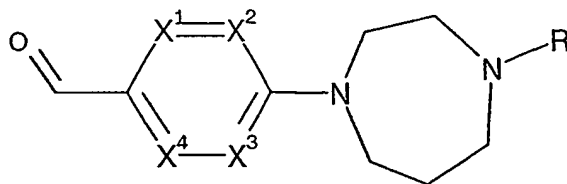
VII

5

or a salt thereof, in which Y<sup>b</sup> is a leaving group for nucleophilic substitution,

or an aldehyde of formula VIII,

10



VIII

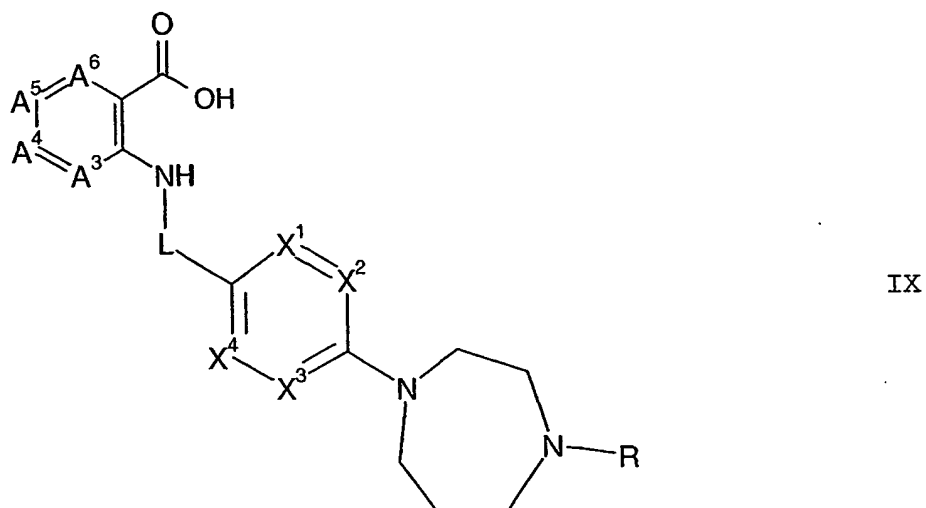
or a salt thereof;

in which X<sup>1</sup>-X<sup>4</sup>, and R have any of the values defined in any of Claims 1-9, or a derivative thereof in which a functional group other than the primary amino group of the compound of formula VI, the leaving group of the compound of formula VII, or the aldehyde group of the compound of formula VII, respectively, is protected using a protecting group.

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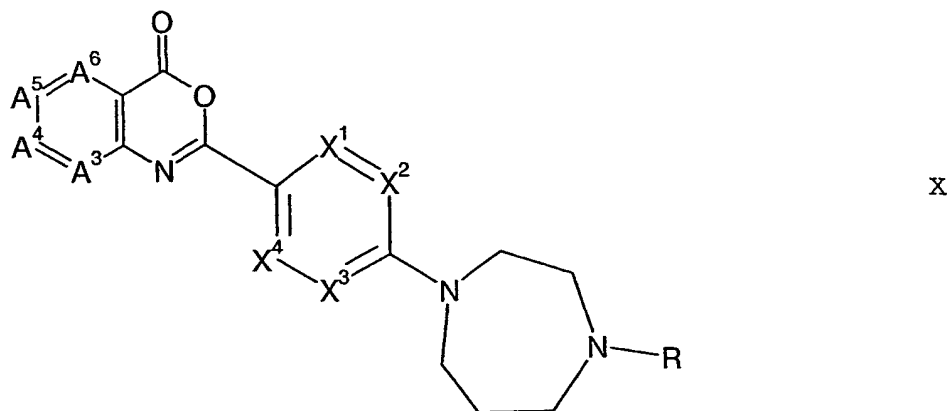
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16. An acid of formula IX,



5 or an activated derivative thereof, or a salt of the acid or  
 activated derivative, in which A<sup>3</sup>-A<sup>6</sup>, L, X<sup>1</sup>-X<sup>4</sup>, and R have  
 any of the values defined in any of Claims 1-9, or a  
 derivative thereof in which a functional group other than  
 the carboxy group, or activated derivative thereof, is  
 10 protected using a protecting group.

17. The activated derivative of Claim 16 which is a  
 compound of formula X,



15

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or a salt of the active derivative, in which A<sup>3</sup>-A<sup>6</sup>, X<sup>1</sup>-X<sup>4</sup>, and R have any of the values defined in any of Claims 1-9, or a derivative thereof in which a functional group other than the activated derivative of the carboxy group is  
5 protected using a protecting group.

18. A compound of formula I (or prodrug or salt) as claimed in any one of Claims 1-10 for use as an antithrombotic agent.

10

19. The use of a compound of formula I (or prodrug or salt) as claimed in any one of Claims 1-10 for the manufacture of a medicament for treatment of a thromboembolic disorder.

15

20. A method of inhibiting factor Xa in a mammal comprising administering to a mammal in need of treatment an effective (factor Xa inhibiting) dose of a compound of formula I (or prodrug or salt) as described in any of Claims  
20 1-10.

21. A compound of formula I substantially as hereinbefore described with reference to any of the examples.

25

22. A process for preparing a compound of formula I substantially as hereinbefore described with reference to any of the examples.

30 23. The use of a compound of formula I substantially as hereinbefore described with reference to any of the examples for the inhibition of factor Xa.

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